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(54) Title: SUBSTITUTED BETA-LACTAM COMPOUNDS USEFUL AS HYPOCHOLESTEROLEMIC AGENTS AND PROCESSES FOR THE PREPARATION THEREOF

(57) Abstract
$$(I) -(CH2)k - N R13$$

$$(Ia) R21 - E R22$$

$$(II)$$

$$R20$$

Novel compounds of formula (I) wherein A is -CH = CH-B; -C≡C-B; -(CH₂)_p-X-B, wherein p is 0-2 and X is a bond, -NH- or -S(O)₀₋₂-; optionally substituted heteroaryl or benzofused heteroaryl; -C(O)-L; or (Ia), wherein k is 1-2; D is $B'-(CH_2)_mC(O)-$, wherein m is 1-5; $B'-(CH_2)_q-$, wherein q is 2-6; $B'-(CH_2)_e-Z-(CH_2)_r-$, wherein Z is -O-, -C(O)-, phenylene, -NR₈- or -S(O)₀₋₂-, e is 0-5 and r is 1-5, provided that the sum of e and r is 1-6; B'-(alkenylene)-; B'-(alkadienylene)-; B'-(CH₂)_t-Z-(alkenylene), wherein t is 0-3, provided that the sum of t and the number of carbon atoms in the alkenylene chain is 2-6; B'-(CH₂)_f-V-(CH₂)_g-, wherein V is cycloalkylene, f is 1-5 and g is 0-5, provided that the sum of f and g is 1-6; B'-(CH₂)_t-V-(alkenylene) or B'-(alkenylene)-V-(CH₂)_t-, provided that the sum of t and the number of carbon atoms in the alkenylene chain is 2-6; B'-(CH₂)_a-Z-(CH₂)_b-V-(CH₂)_d-, wherein a, b and d are 0-6, provided that the sum of a, b and d is 0-6; T-(CH₂)₅-, wherein T is cycloalkyl and s is 1-6; naphthylmethyl or optionally substituted heteroarylmethyl; B is optionally substituted phenyl; B' is naphthyl, optionally substituted heteroaryl or optionally substituted phenyl; R is hydrogen, fluoro, alkyl, alkenyl, alkynyl, or B-(CH₂)h-, wherein h is 0-3; R₄ is optionally substituted phenyl, indanyl, benzofuranyl, tetrahydronaphthyl, pyridyl, pyrazinyl, pyrimidinyl or quinolyl; are disclosed, as well as their use as hypocholesterolemic agents; the method of using compounds of formula (II), wherein R₂₀ is optionally substituted phenyl, optionally substituted naphthyl, optionally substituted heteroaryl, or optionally substituted benzofused heteroaryl, R21, R22 and R23 are independently selected from H or R20; E, F and G are independently a bond; cycloalkylene; alkylene; alkenylene; alkynylene; a substituted alkylene, alkenylene or alkynylene chain; an interrupted alkylene, alkenylene or alkynylene chain; or an interrupted alkylene, alkenylene or alkynylene chain substituted by one or more substituents; or one of R21-E and R22-F is selected from the group consisting of halogeno, OH, alkoxy, -OC(O)R5, -NR10R11, -SH or -S(alkyl); R5 is alkyl, phenyl, R₁₄-phenyl, benzyl or R₁₄-benzyl; R₁₀ and R₁₁ are independently selected from H and lower alkyl, or a pharmaceutically acceptable salt thereof, in a pharmaceutically acceptable carrier as hypocholesterolemic agents is also disclosed.

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SUBSTITUTED BETA-LACTAM COMPOUNDS USEFUL AS HYPOCHOLESTEROLEMIC AGENTS AND PROCESSES FOR THE PREPARATION THEREOF

BACKGROUND OF THE INVENTION

The present invention relates to substituted β -lactams useful as hypocholesterolemic agents in the treatment and prevention of atherosclerosis and to processes for preparing β -lactams.

Atherosclerotic coronary heart disease represents the major cause for death and cardiovascular morbidity in the western world. Risk factors for atherosclerotic coronary heart disease include hypertension, diabetes mellitus, family history, male sex, cigarette smoking and serum cholesterol. A total cholesterol level in excess of 225-250 mg/dl is associated with significant elevation of risk.

Cholesteryl esters are a major component of atherosclerotic lesions and the major storage form of cholesterol in arterial wall cells. Formation of cholesteryl esters is also a key step in the intestinal absorption of dietary cholesterol. The intracellular esterification of cholesterol is catalyzed by the enzyme acyl CoA:cholesterol acyl transferase (ACAT, EC 2.3.1.26). Thus, inhibition of ACAT is likely to inhibit the progression of atherosclerotic lesion formation, decrease the accumulation of cholesteryl esters in the arterial wall, and block the intestinal absorption of dietary cholesterol.

A few β-lactam compounds have been reported as being useful in lowering cholesterol and/or in inhibiting the formation of cholesterol-containing lesions in mammalian arterial walls. U.S. 4,983,597 discloses N-sulfonyl-2-azetidinones as anticholesterolemic agents and Ram, et al., in <u>Indian J Chem. Sect. B. 29B</u>, 12 (1990), p. 1134-7, disclose ethyl 4-(2-oxoazetidin-4-yl)phenoxy-alkanoates as hypolipidemic agents. European Patent Publication 264,231 discloses

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1-substituted-4-phenyl-3-(2-oxoalkylidene)-2-azetidinones as blood platelet aggregation inhibitors.

SUMMARY OF THE INVENTION

Novel hypocholesterolemic compounds of the present invention are represented by the formula I

wherein

A is -CH=CH-B;

-C≡C-B:

-(CH₂)_p-X-B, wherein p is 0, 1 or 2 and X is a bond, -NH- or -S(O)₀₋₂-;

heteroaryl, benzofused heteroaryl, W-substituted heteroaryl or W-substituted benzofused heteroaryl, wherein heteroaryl is selected from the group consisting of pyrrolyl, pyridinyl, pyrimidinyl, pyrazinyl, triazinyl, imidazolyl, thiazolyl, pyrazolyl, thienyl, oxazolyl and furanyl, and for nitrogen-containing heteroaryls, the N-oxides thereof, and wherein W is 1-3 substituents on the ring carbon atoms selected from the group consisting of lower alkyl, hydroxy lower alkyl, lower alkoxy, alkoxyalkyl, alkoxyalkoxy, alkoxycarbonylalkoxy, (lower alkoxy-imino)lower alkyl, lower alkanedioyl, lower alkyl lower alkanedioyl, allyloxy, -CF3, -OCF3, benzyl, R14-benzyl, benzyloxy, R14-benzyloxy, phenoxy, R14-phenoxy, dioxolanyl, NO2, -NR10R11, NR10R11(lower alkyl)-, NR10R11(lower alkoxy)-, OH, halogeno, -NHC(O)OR5, -NHC(O)R5, R6O2SNH-, (R6O2S)2N-, -S(O)2NH2, -S(O)0-2R10, tert-butyldimethylsilyloxymethyl,

-C(O)R₁₂ and -CH₂-N R₁₃, and wherein the substituents on the substituted heteroaryl ring nitrogen atoms, when present, are selected from the group consisting of lower alkyl, lower alkoxy, -C(O)OR₅, -

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B is

 $C(O)R_5$, OH, $NR_{10}R_{11}$ (lower alkyl)-, $NR_{10}R_{11}$ (lower alkoxy)-, -S(O)₂NH₂ and 2-(trimethylsilyl)ethoxymethyl;

-C(O)-B; or
$$R_{13}$$
, wherein k is 1 or 2;

D is B'- $(CH_2)_mC(O)$ -, wherein m is 1, 2, 3, 4 or 5;

B'- $(CH_2)_{q}$ -, wherein q is 2, 3, 4, 5 or 6;

B'-(CH₂)_e-Z-(CH₂)_r, wherein Z is -O-, -C(O)-, phenylene, -NR₈- or -S(O)₀₋₂-, e is 0, 1, 2, 3, 4 or 5 and r is 1, 2, 3, 4 or 5, provided that the sum of e and r is 1, 2, 3, 4, 5 or 6;

B'-(C2-C6 alkenylene)-; B'-(C4-C6 alkadienylene)-;

B'- $(CH_2)_{t}$ -Z- $(C_2$ - C_6 alkenylene)-, wherein Z is as defined above, and wherein t is 0, 1, 2 or 3, provided that the sum of t and the number of carbon atoms in the alkenylene chain is 2, 3, 4, 5 or 6;

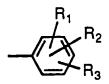
B'- $(CH_2)_f$ -V- $(CH_2)_g$ -, wherein V is C₃-C₆ cycloalkylene, f is 1, 2, 3, 4 or 5 and g is 0, 1, 2, 3, 4 or 5, provided that the sum of f and g is 1, 2, 3, 4, 5 or 6;

 $B'-(CH_2)_t-V-(C_2-C_6$ alkenylene)- or $B'-(C_2-C_6$ alkenylene)- $V-(CH_2)_t-$, wherein V and t are as defined above, provided that the sum of t and the number of carbon atoms in the alkenylene chain is 2, 3, 4, 5 or 6;

B'- $(CH_2)_a$ -Z- $(CH_2)_b$ -V- $(CH_2)_d$ -, wherein Z and V are as defined above and a ,b and d are independently 0, 1, 2, 3, 4, 5 or 6, provided that the sum of a, b and d is 0, 1, 2, 3, 4, 5 or 6;

T-(CH₂)_s-, wherein T is cycloalkyl of 3-6 carbon atoms and s is 1, 2, 3, 4, 5 or 6; or

naphthylmethyl, heteroarylmethyl, or W-substituted heteroarylmethyl, wherein heteroaryl and W are as defined above;



B' is naphthyl, heteroaryl or W-substituted heteroaryl, wherein heteroaryl is as defined above, or

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R is hydrogen, fluoro, C_1 - C_{15} alkyl, C_1 - C_{15} alkenyl, C_1 - C_{15} alkynyl, or B-(CH₂)_h-, wherein h is 0, 1, 2, or 3;

R₁, R₂ and R₃ are independently selected from the group consisting of H, lower alkyl, hydroxy lower alkyl, lower alkoxy, alkoxyalkyl, alkoxyalkoxy, alkoxycarbonylalkoxy, (lower alkoxyimino)-lower alkyl, lower alkanedioyl, lower alkyl lower alkanedioyl, allyloxy, -CF₃, -OCF₃, benzyl, R₁₄-benzyl, benzyloxy, R₁₄-benzyloxy, phenoxy, R₁₄-phenoxy, dioxolanyl, NO₂, -NR₁₀R₁₁, NR₁₀R₁₁(lower alkyl)-, NR₁₀R₁₁(lower alkoxy)-, OH, o-halogeno, m-halogeno, -NHC(O)OR₅, -NHC(O)R₅, R₆O₂SNH-, (R₆O₂S)₂N-, -S(O)₂NH₂, -S(O)₀-2R₁₀, tert-

butyldimethylsilyloxymethyl, -C(O)R₁₂, -CH₂-N R₁₃ and

 $-\ddot{C}-N$ R_{13} , or R_1 is hydrogen and R_2 and R_3 , together with adjacent carbon atoms to which they are attached, form a dioxolanyl ring;

R₁', R₂' and R₃' are independently selected from the group consisting of H, lower alkyl, hydroxy lower alkyl, lower alkoxy, alkoxyalkoxy, alkoxycarbonylalkoxy, (lower alkoxyimino)-lower alkyl, lower alkanedioyl, lower alkyl alkanedioyl, allyloxy, -CF₃, -OCF₃, benzyl, R₁₄-benzyl, benzyloxy, R₁₄-benzyloxy, phenoxy, R₁₄-phenoxy, dioxolanyl, NO₂, -NR₁₀R₁₁, NR₁₀R₁₁(lower alkyl)-, NR₁₀R₁₁(lower alkoxy)-, OH, halogeno, -NHC(O)OR₅, -NHC(O)R₅, R₆O₂SNH-, (R₆O₂S)₂N-, -S(O)₂NH₂, -S(O)₀₋₂R₁₀, tert-butyldimethyl-

silyloxymethyl, $-C(O)R_{12}$, R_{13} and R_{13} , or R_{1} is hydrogen and R_{2} and R_{3} , together with adjacent carbon atoms to which they are attached, form a dioxolanyl ring;

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alkyl;

(R₇)_n

, wherein n is 0, 1, 2 or 3, indanyl,

benzofuranyl, benzodioxolyl, tetrahydronaphthyl, pyridyl, pyrazinyl, pyrimidinyl or quinolyl;

R₅ is lower alkyl, phenyl, R₁₄-phenyl, benzyl or R₁₄-benzyl; R₆ is OH, lower alkyl, phenyl, benzyl, R₁₄-phenyl or R₁₄-benzyl; R₇ is lower alkyl, lower alkoxy, OH, halogeno, -NR₁₀R₁₁, -NHC(O)OR₅, -NHC(O)R₅, NO₂, -CN, -N₃, -SH, -S(O)₀₋₂-(lower alkyl), -COOR₉, -CONR₁₀R₁₁, -COR₁₂, phenoxy, benzyloxy, -OCF₃, or tert-butyldimethylsilyloxy, and where n is 2 or 3, the R₇ groups can be the same or different;

R₈ is H, lower alkyl, phenyl lower alkyl, or -C(O)R₉;
R₉ is H, lower alkyl, phenyl or phenyl lower alkyl;
R₁₀ and R₁₁ are independently selected from H and lower

R₁₂ is H, OH, alkoxy, phenoxy, benzyloxy,
-NR₁₀R₁₁, lower alkyl, phenyl or R₁₄-phenyl;

R₁₃ is -O-, -CH₂-, -NH- or -N(lower alkyl)-; and R₁₄ is 1-3 groups independently selected from the group consisting of lower alkyl, lower alkoxy, -COOH, NO₂, -NR₁₀R₁₁, OH or halogeno;

or a pharmaceutically acceptable salt thereof.

Preferred are compounds of formula I wherein R is H.

Another group of preferred compounds of formula I is that wherein D is

B'-(CH₂)_q-, B'-(CH₂)_e-Z-(CH₂)_r-, B'-(C₂-C₆ alkenylene)-,

or B'-(CH₂)_f-V-(CH₂)_g-, wherein B', Z, V, q, e, r, f, and g are as defined above. A third group of preferred compounds of formula I is that wherein R₄ is phenyl, R₇-substituted phenyl or indanyl. Still another group of preferred compounds of formula I is that wherein A is -(CH₂)_p-X-B,

wherein X, B and p are as defined above.

Especially preferred are compounds of formula I wherein D is: B'-(CH₂)_q-, wherein B' is phenyl and q is 3 or 4; B'-(CH₂)_e-Z-(CH₂)_{Γ},

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wherein B' is p-fluorophenyl or p-methoxyphenyl, e is zero, Z is -O-, and r is 2; B'-(C_2 - C_6 alkenylene)- is 3-phenyl-1-propenyl; or B'-(CH_2)_f-V-(CH_2)_g-, wherein B' is phenyl, f is 1, V is cyclopropylene, and g is zero. Also especially preferred are compounds of formula I wherein A is -(CH_2)_p-X-B wherein p is zero and X is a bond. Preferably R₁, R₂ and R₃ are selected from H, OH, -NO₂, lower alkoxy, alkoxyalkoxy, lower alkyl lower alkandioyl, m-halogeno, NR₁₀R₁₁(lower alkoxy)-, allyloxy, phenoxy, alkoxycarbonylalkoxy and -C(O)R₁₂. Compounds wherein R₁ and R₃ are each H and R₂ is in the para-position are more preferred.

 R_7 is preferably selected from lower alkyl, lower alkoxy, halogeno, -OCF₃, lower alkylthio, -NR₁₀R₁₁, -CN, OH, and -COR₁₂. More preferred are compounds wherein n is 1 and R_7 is in the paraposition.

Especially preferred compounds of formula I, wherein R is hydrogen, are shown in the following Table 1:

hydrogen, are snown ii	The following rable i.	1
D	Α	R ₄
C ₆ H ₅ -(CH ₂) ₃ -	p-CH ₃ O-C ₆ H ₄ -	p-CH ₃ O-C ₆ H ₄ -
C ₆ H ₅ -(CH ₂) ₄ -	p-CH ₃ O-C ₆ H ₄ -	p-CH ₃ O-C ₆ H ₄ -
C ₆ H ₅ -(CH ₂) ₃ -	p-CH ₃ O-C ₆ H ₄ -	C ₆ H ₅ -
C ₆ H ₅ -(CH ₂) ₃ -	p-OH-C ₆ H ₄ -	p-CH ₃ O-C ₆ H ₄ -
C ₆ H ₅ -(CH ₂) ₃ -	p-CH ₃ O-C ₆ H ₄ -	p-CI-C ₆ H ₄ -
C ₆ H ₅ -(CH ₂) ₃ -	p-CH ₃ CH ₂ -O-C ₆ H ₄ -	p-CH ₃ O-C ₆ H ₄ -
C ₆ H ₅ -(CH ₂) ₃ -	p-CH ₃ O-C ₆ H ₄ -	p-CH3CH2O-C6H4-
p-F-C ₆ H ₄ -O-(CH ₂) ₂ -	p-CH ₃ O-C ₆ H ₄ -	p-CH ₃ O-C ₆ H ₄ -
C ₆ H ₅ -(CH ₂) ₃ -	p-CH ₃ O-C ₆ H ₄ -	p-F-C ₆ H ₄ -
C ₆ H ₅ -(CH ₂) ₃ -	p-CH ₃ O-C ₆ H ₄ -	m-CH ₃ O-C ₆ H ₄ -
C ₆ H ₅ -(CH ₂) ₃ -	p-CH ₃ O-C ₆ H ₄ -	p-CF ₃ O-C ₆ H ₄ -
C ₆ H ₅ -(CH ₂) ₃ -	p-CH ₃ O-C ₆ H ₄ -	p-CH ₃ -C ₆ H ₄ -
C ₆ H ₅ -CH ₂ -CH=CH-	p-CH ₃ O-C ₆ H ₄ -	p-CH ₃ O-C ₆ H ₄ -
C ₆ H ₅ -(CH ₂) ₃ -	p-(CH ₃ (CH ₂) ₃)-O-C ₆ H ₄ -	p-CH ₃ O-C ₆ H ₄ -
C ₆ H ₅ -(CH ₂) ₃ -	p-CH ₃ O-C ₆ H ₄ -	p-CH ₃ S-C ₆ H ₄ -
C ₆ H ₅ -(CH ₂) ₃ -	p-(CH ₂ =CH-CH ₂ -O)-C ₆ H ₄ -	p-CH ₃ O-C ₆ H ₄ -
C ₆ H ₅ -(CH ₂) ₃ -	p-(C ₆ H ₅ -O)-C ₆ H ₄ -	p-CH ₃ O-C ₆ H ₄ -
C ₆ H ₅ -(CH ₂) ₃ -	p-(CH ₃ CH ₂ O ₂ C)-C ₆ H ₄ -	p-CH ₃ O-C ₆ H ₄ -

D	Α	R ₄
C ₆ H ₅ -(CH ₂) ₃ -	p-CH ₃ O-C ₆ H ₄ -	O
C ₆ H ₅ -(CH ₂) ₃ -	p-(CH ₃ CH ₂ CH ₂ -O)-C ₆ H ₄ -	p-CH ₃ O-C ₆ H ₄ -
C ₆ H ₅ -(CH ₂) ₅ -	p-CH ₃ O-C ₆ H ₄ -	p-CH ₃ O-C ₆ H ₄ -
C ₆ H ₅ -(CH ₂) ₃ -	p-CH ₃ O-C ₆ H ₄ -	p-((CH ₃ CH ₂) ₂ N)- C ₆ H ₄ -
C ₆ H ₅ -(CH ₂) ₃ -	p-(CH ₃ CH ₂ O)-C ₆ H ₄ -	C ₆ H ₅ -
CH ₂ CH— CH—	p-CH ₃ O-C ₆ H ₄ -	p-CH ₃ O-C ₆ H ₄ -
C ₆ H ₅ -(CH ₂)3-	p-((CH ₃) ₂ CH-O)-C ₆ H ₄ -	p-CH ₃ O-C ₆ H ₄ -
p-F-C ₆ H ₄ -O-(CH ₂) ₂ -	p-CH ₃ O-C ₆ H ₄ -	C ₆ H ₅ -
C ₆ H ₅ -(CH ₂) ₃ -	p-CH ₃ O-C ₆ H ₄ -	N≡C-{\bar{\bar{\bar{\bar{\bar{\bar{\bar
C ₆ H ₅ -(CH ₂) ₃ -	p-(CH ₃ O ₂ C)-C ₆ H ₄ -	C ₆ H ₅ -
C ₆ H ₅ -(CH ₂) ₃ -	p-CH ₃ O-C ₆ H ₄ -	
C ₆ H ₅ -(CH ₂) ₃ -	H ₃ CO OCH ₃	p-CH ₃ O-C ₆ H ₄ -
C ₆ H ₅ -(CH ₂) ₃ -	p-CH ₃ O-C ₆ H ₄ -	p-(H3CC(O))-C6H4-
C ₆ H ₅ -(CH ₂) ₃ -	-€-CH3	p-CH ₃ O-C ₆ H ₄ -
C ₆ H ₅ -(CH ₂) ₃ -	p-(CH ₃ OCH ₂ O)-C ₆ H ₄ -	C ₆ H ₅ -
p-CH3O-C6H4-O-(CH2)2-	p-CH ₃ O-C ₆ H ₄ -	C ₆ H ₅ -
C ₆ H ₅ -(CH ₂) ₃ -	p-(CH ₃ CH ₂ OC(O)CH ₂ O)- C ₆ H ₄ -	p-CH ₃ O-C ₆ H ₄ -
C ₆ H ₅ -(CH ₂) ₃ -	p-(CH ₃ OC(O)-(CH ₂) ₂ - C(O)-O)-C ₆ H ₄ -	p-CH ₃ O-C ₆ H ₄ -
C ₆ H ₅ -(CH ₂) ₃ -	p-((CH ₃) ₂ N-(CH ₂) ₃ -O)- C ₆ H ₄ -	p-CH ₃ O-C ₆ H ₄ -
C ₆ H ₅ -(CH ₂) ₃ -	p-HO-C ₆ H ₄ -	p-HO-C ₆ H ₄ -
	p-CH ₃ O-C ₆ H ₄ -	C ₆ H ₅ -

The first-listed compound in the above table having the (3R,4S) absolute stereochemistry is more preferred.

This invention also relates to the use of a novel compound of formula I of the present invention as a hypocholesterolemic agent in a mammal in need of such treatment.

In another aspect, the invention relates to a pharmaceutical composition comprising a novel β -lactam of formula I of the present invention in a pharmaceutically acceptable carrier.

In still another aspect, the present invention relates to a

pharmaceutical composition comprising a cholesterol-lowering effective amount of a compound having the structural formula II

wherein

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R₂₀ is phenyl, W-substituted phenyl, naphthyl, W-substituted naphthyl, benzodioxolyl, heteroaryl, W-substituted heteroaryl, benzofused heteroaryl and W-substituted benzofused heteroaryl, wherein heteroaryl is selected from the group consisting of pyrrolyl, pyridinyl, pyrimidinyl, pyrazinyl, triazinyl, imidazolyl, thiazolyl, pyrazolyl, thienyl, oxazolyl and furanyl, and for nitrogen-containing heteroaryls, the N-oxides thereof;

R₂₁, R₂₂ and R₂₃ are independently selected from H or R₂₀;

W is 1 to 3 substituents independently selected from the group consisting of lower alkyl, hydroxy lower alkyl, lower alkoxy, alkoxyalkyl, alkoxyalkoxy, alkoxycarbonylalkoxy, (lower alkoxyimino)-lower alkyl, lower alkanedioyl, lower alkyl lower alkanedioyl, allyloxy, -CF₃, -OCF₃, benzyl, R₁₄-benzyl, benzyloxy, R₁₄-benzyloxy, phenoxy, R₁₄-phenoxy, dioxolanyl, NO₂, -NR₁₀R₁₁, NR₁₀R₁₁(lower alkyl)-, NR₁₀R₁₁(lower alkoxy)-, OH, halogeno, -NHC(O)OR₅, -NHC(O)R₅,

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R₆O₂SNH-, (R₆O₂S)₂N-, -S(O)₂NH₂, -S(O)₀₋₂R₁₀, tert-butyldimethyl-

silyloxymethyl, -C(O)R₁₂, $-CH_2-N$ R_{13} and -C-N R_{13}

E, F and G are independently a bond; C3-C6 cycloalkylene; C1-C10 alkylene; C1-C10 alkylene; C1-C10 alkylene; C1-C10 alkynylene; an alkylene, alkenylene or alkynylene chain as defined substituted by one or more substituents independently selected from the group consisting of phenyl, W-substituted phenyl, heteroaryl and W-substituted heteroaryl, wherein heteroaryl is as defined above; an alkylene, alkenylene or alkynylene chain as defined interrupted by one or more groups independently selected from the group consisting of -O-, -S-, -SO-, -SO2-, -NR8, -C(O)-, C3-C6 cycloalkylene, phenylene, W-substituted phenylene, heteroarylene and W-substituted heteroarylene; or an interrupted alkylene, alkenylene or alkynylene chain as defined substituted by one or more substituents independently selected from the group consisting of phenyl, W-substituted phenyl, heteroaryl and W-substituted heteroaryl; or one of R21-E and R22-F is selected from the group consisting of halogeno, OH, lower alkoxy, -OC(O)R5,

 R_5 is lower alkyl, phenyl, R_{14} -phenyl, benzyl or R_{14} -benzyl; R_6 is OH, lower alkyl, phenyl, benzyl, R_{14} -phenyl or R_{14} -

R₈ is H, lower alkyl, phenyl lower alkyl or -C(O)R₉; R₉ is H, lower alkyl, phenyl or phenyl lower alkyl; R₁₀ and R₁₁ are independently selected from H and lower

25 alkyl;

benzyl;

R₁₂ is H, OH, alkoxy, phenoxy, benzyloxy,

-NR₁₀R₁₁, lower alkyl, phenyl or R₁₄-phenyl;

 $-NR_{10}R_{11}$, -SH or -S(lower alkyl);

R₁₃ is -O-, -CH₂-, -NH- or -N(lower alkyl)-;

R₁₄ is 1-3 groups independently selected from the group consisting of lower alkyl, lower alkoxy, -COOH, NO₂, -NR₁₀R₁₁, OH or halogeno;

provided that when G is a bond, R₂₃ is not H, and provided that when R₂₃ is W-substituted phenyl, W is not p-halogeno; or a pharmaceutically acceptable salt thereof; in a pharmaceutically acceptable carrier.

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It is noted that novel compounds of formula I are included within the scope of formula II.

Preferred compounds of formula II are those wherein R_{21} is H and E is a bond or lower alkylene, and those wherein R_{21} is phenyl and E is lower alkylene. Also preferred are compounds of formula II wherein R_{22} is H and F is a bond. Another group of preferred compounds of formula II is that wherein G is a bond and R_{23} is phenyl substituted by OH, -NO₂, lower alkoxy, alkoxyalkoxy, m-halogeno, lower alkyl lower alkandioyl, NR₁₀R₁₁(lower alkoxy)-, allyloxy, phenoxy, alkoxycarbonylalkoxy, and -C(O)R₁₂. Still another group of preferred compounds of formula II is that wherein R_{20} is phenyl or phenyl substituted by lower alkyl, lower alkoxy, halogeno, -OCF₃, lower alkylthio, -NR₁₀R₁₁, -CN, OH or acetyl.

Certain compounds not within the scope of formula I but within the scope of formula II are novel compounds. Examples of such compounds are represented in the following Table 2

compounds are	represented in the		1 5
R ₂₁ -E-	R ₂₂ -F-	R ₂₃ -G-	R ₂₀ -
C ₁₀ H ₂₁ -	Н	C ₆ H ₅ -	4-CH ₃ O-C ₆ H ₄ -
C ₁₀ H ₂₁ -	Н	C ₆ H ₅ -	2,4,6-tri-CH ₃ O-
C101121			C ₆ H ₂ -
C ₁₀ H ₂₁ -	CH ₃ CH ₂ -	C ₆ H ₅ -	4-CH ₃ O-C ₆ H ₄ -
	C ₆ H ₅ -(CH ₂) ₃ -	C ₆ H ₅ -	4-CH ₃ O-C ₆ H ₄ -
C ₁₀ H ₂₁ -	CH ₃ CH ₂ -	C ₆ H ₅ -	2,4,6-tri-CH ₃ O-
C1011215	. 5.1.0=12		C ₆ H ₂ -
C ₁₀ H ₂₁ -	CH ₃ CH ₂ -	C ₆ H ₅ -CH=CH-	4-CH ₃ O-C ₆ H ₄ -
C ₁₀ H ₂₁ -	CH ₃ -	C ₆ H ₅ -	4-CH ₃ O-C ₆ H ₄ -
0101121	į	•	

The present invention also relates to the method of lowering serum cholesterol in a mammal in need of such treatment

comprising administering a pharmaceutical composition comprising a compound of formula II in a pharmaceutically acceptable carrier.

The present invention also relates to the use of a compound of formula I or II as an ACAT inhibitor.

The present invention also relates to a stereoselective process for producing β-lactams of formula I, wherein R is hydrogen ,and D and A have trans relative stereochemistry, from a hydroxyamide of the formula

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wherein D, A and R4 are as defined above, by cyclizing the hydroxyamide, and wherein the hydroxyamide is prepared from a carboxylic acid DCH₂COOH, an aldehyde A-CHO and an amine R⁴NH₂, wherein D, A and R4 are as defined above, in a process utilizing as a chiral auxiliary an oxazolidinone of the formula

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wherein R¹⁸ and R¹⁹ are independently selected from the group consisting of: hydrogen, C₁-C₆ alkyl, phenyl, naphthyl, substituted phenyl, substituted naphthyl, and benzyl, wherein said chiral auxiliary is preferably R-(+)-4-benzyl-oxazolidinone.

This process, designated Method D, for producing compounds of formula I, wherein R is hydrogen, and D and A have trans relative stereochemistry, comprises the steps:

reacting a carboxylic acid of the formula D-CH2COOH, wherein D is as defined above, with a chlorinating agent;

		(b)	deprotonating a chiral oxazolidinone, as described
	above, prefe	rably F	R-(+)-4-benzyloxazolidinone, with a strong base or a
		e base	and treating the resulting anion with the product of
	step (a);		is the anadust of stop (b) with either
5		(c)	enolizing the product of step (b) with either:
			(i) a dialkylboron triflate and a tertiary amine base;
			or (ii) TiCl ₄ and tetramethylethylenediamine (TMEDA)
			or a mixture of TMEDA and triethylamine;
		46	condensing with an aldehyde of the formula A-CHO,
10	wherein A is		
	wnerein A is	(d)	hydrolyzing the product of step (c) with a base and
	hudrogen no	` '	
	hydrogen pe	(e)	condensing the product of step (d) with an amine of
4 5	the fermula E		, wherein R ⁴ is as defined above, by treating with a
15	debudrative	countin	ng agent, optionally adding an activating agent;
	deligurative	(f)	cyclizing the product of step (e) by reacting the
	product of ste	• •	
	product or ste	SP (C)	(i) a dialkylazodicarboxylate and a
20			trialkylphosphine; or
20			(ii) a di- or tri-chlorobenzoyl chloride, an aqueous
			solution of a base and a phase transfer catalyst,
			then treating the resulting di- or tri-chlorobenzoate
			with an aqueous solution of a base and a phase
25			transfer catalyst; or
			(iii) a dialkylchlorophosphate, an aqueous solution
			of a base and a phase transfer catalyst; or
			(iv) a di- or tri-chlorobenzoyl chloride and a metal
			hydride.
30		In and	other embodiment, the process of this invention
	provides the	steps	of producing a β-lactam of formula I, wherein R is
	hydrogen, an	id D ar	nd A have trans relative stereochemistry, from a β-
	aminoamide	deriva	tive of the formula

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$$R^{6} \xrightarrow{Q} Q \xrightarrow{\underline{D}} A$$

$$R^{7} \qquad Q \qquad HN \qquad R^{4}$$

by cyclizing the β-aminoamide, wherein the β-aminoamide is prepared from a carboxylic acid DCH₂COOH, and an imine ACH=N-R⁴, wherein D, A and R⁴ are as defined above, in a process utilizing as a chiral auxiliary an oxazolidinone of the formula

wherein R¹⁸ and R¹⁹ are as defined above, and wherein said chiral auxiliary is preferably R-(+)-4-benzyl-oxazolidinone.

This process, designated Method F, for producing compounds of formula I, wherein R is hydrogen, and D and A have trans relative stereochemistry, comprises the steps:

- (a) enolizing the product of Method D, step (b) with TiCl₄ and tetramethylethylenediamine (TMEDA), then condensing with an imine of the formula A-CH=N-R⁴, wherein A and R⁴ are as defined above;
- (b) cyclizing the product of step (a) by treating with a strong non-nucleophilic base, preferably sodium bistrimethylsilylamide.

DETAILED DESCRIPTION:

As used herein, the term "lower alkyl" means straight or branched alkyl chains of 1 to 6 carbon atoms and "lower alkyoxy" similarly refers to alkoxy groups having 1 to 6 carbon atoms.

"Alkenyl" means straight or branched carbon chains having one or more double bonds in the chain, conjugated or unconjugated,

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and alkadienyl refers to chains having two double bonds in the chain. Similarly, "alkynyl" means straight or branched carbon chains having one or more triple bonds in the chain.

Where an alkyl, alkenyl or alkynyl chain joins two other variables and is therefore bivalent, the terms alkylene, alkenylene and alkynylene are used.

"Cycloalkyl" means a saturated carbon ring of 3 to 6 carbon atoms, while "cycloalkylene" refers to a corresponding bivalent ring, wherein the points of attachment to other groups include all positional isomers.

"Halogeno" refers to fluorine, chlorine, bromine or iodine radicals.

"Heteroaryl" includes all positional isomers for a given heteroaryl group as defined above, for example 2-pyridyl, 3-pyridyl and 4-pyridyl. Benzofused heteroaryl refers to radicals formed by the bonding of a benzene radical to adjacent carbon atoms on a heteroaryl ring; examples are indolyl, quinolyl, quinazolinyl, quinoxalinyl, benzotriazolyl, indazolyl, benzoxazolyl, benzothienyl and benzofuranyl.

"Phenylene" means a bivalent phenyl group, including ortho, meta and para-substitution and "heteroarylene" similarly means a bivalent heteroaryl group, ioncluding all positional isomers.

"(Lower alkoxyimino)lower alkyl" refers to the group (C₁-C₆ lower alkoxy)-N=CH-(C₁-C₅ lower alkyl). "Lower alkanedioyl" means radicals of the formula -OC(O)(CH₂)₁₋₄C(O)OH, while "lower alkyl lower alkanedioyl" means radicals of the formula -OC(O)(CH₂)₁₋₄C(O)O-(lower alkyl).

 R_{14} -benzyl and R_{14} -benzyloxy refer to benzyl and benzyloxy radicals which are substituted on the phenyl ring.

"Tertiary amine base" means a trialkylamine, such as triethylamine or diisopropylethylamine, or a nitrogen containing heterocycle, such as pyridine.

"Base" means a metal hydroxide base such as lithium, sodium or potassium hydroxide

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"Strong base" means a non-aqueous base such as a metal hydride or an alkyllithium.

"Metal hydride" means a commercially available metal hydride such as lithium, sodium or potassium hydride

"Alkyllithium" means a alkyllithium reagent such as n-butyllithium, s-butyllithium, t-butyllithium or methyllithium.

""Dehydrative coupling agent" means a carbodiimide such as 1-(3'-dimethylaminopropyl)-3-ethylcarbodiimide hydrochloride (DEC) or dicyclohexylcarbodiimide (DCC).

"Activating agent" means an agent used to facilitate the formation of amide bonds such as 1-hydroxybenzotriazole (HOBT) or N-hydroxysuccinimide.

"Halide salt" means a metal salt of a halogen such as sodium, lithium or potassium bromide.

The carbon chains as defined in E, F, and G, when substituted by optionally substituted phenyl or heteroaryl groups, may include independent substitution on different carbon atoms, disubstitution on one carbon atom, or both. One skilled in the art will recognize that the number of double or triple bonds present, the replacement of carbon atoms in the chain and the presence of substitutents on the carbon atoms in the chain are all dependent on the length of the chain: shorter carbon chains cannot accommodate as many double or triple bonds, carbon replacements or substituents as longer carbon chains can. In general, unsaturated carbon chains contain 1 to 4 double or triple bonds, conjugated or non-conjugated. Where carbon atoms are replaced, 1 to 4 replacement groups can be present. Similarly, when carbon atoms in the chain are substituted, 1 to 4 substituents can be present.

Examples of alkyl chains are methyl, ethyl, propyl, butyl and decyl.

Examples of unsaturated E, F and G groups are ethylene and acetylene.

Examples of E, F and G groups wherein the carbon atoms in the chain are replaced are -CH₂CH₂O-, -OCH₂CH₂-, -CH₂O-,

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-CH₂CH₂CH₂O-, -CH₂-O-CH₂-, -CH₂CH₂-O-CH₂, -CH₂CH₂-NH-, -CH₂CH₂-N(CH₃)- and -O-CH₂C(O)-NH-.

Compounds of the invention have at least one asymmetrical carbon atom and therefore all isomers, including diastereomers and rotational isomers are contemplated as being part of this invention. The invention includes d and I isomers in both pure form and in admixture, including racemic mixtures. Isomers can be prepared using conventional techniques, either by reacting enantiomeric starting materials or by separating isomers of a compound of formula I or II.

Isomers may include geometric isomers, e.g. when E, F or G contains a double bond. All such isomers are contemplated for this invention.

Those skilled in the art will appreciate that for some compounds of formulae I and II, one isomer will show greater pharmacological activity than another isomer.

Compounds of the invention with an amino group can form pharmaceutically acceptable salts with organic and inorganic acids. Examples of suitable acids for salt formation are hydrochloric, sulfuric, phosphoric, acetic, citric, oxalic, malonic, salicylic, malic, fumaric, succinic, ascorbic, maleic, methanesulfonic and other mineral and carboxylic acids well known to those in the art. The salt is prepared by contacting the free base form with a sufficient amount of the desired acid to produce a salt. The free base form may be regenerated by treating the salt with a suitable dilute aqueous base solution such as dilute aqueous sodium bicarbonate. The free base form differs from its respective salt form somewhat in certain physical properties, such as solubility in polar solvents, but the salt is otherwise equivalent to its respective free base forms for purposes of the invention.

Certain compounds of the invention are acidic (e.g., those compounds which possess a carboxyl group). These compounds form pharmaceutically acceptable salts with inorganic and organic bases. Examples of such salts are the sodium, potassium, calcium, aluminum, gold and silver salts. Also included are salts formed with

pharmaceutically acceptable amines such as ammonia, alkyl amines, hydroxyalkylamines, N-methylglucamine and the like.

Compounds of formulae I and II can be prepared by several known methods, and in particular compounds having trans stereochemistry can be prepared by a novel method D, as disclosed in U.S. Serial No. 07/734,426, filed July 23, 1991, or novel method F.

Method A:

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Compounds of formula la and lb, wherein A, D, R and R₄ are as defined above, can be prepared by treatment of an ester of formula V, wherein R₁₅ is lower alkyl such as ethyl or a chiral moiety such as menthyl or 10-(diisopropylsulfonamido)-isobornyl, with a strong base such as lithium diisopropylamide in a suitable solvent such as tetrahydrofuran (THF) at -78°C. Hexamethylphosphoric triamide (HMPA) may optionally be added as a cosolvent. An imine of formula IV is added and the reaction mixture is warmed to room temperature and the product isolated using conventional purification techniques. When a chiral ester of formula V is used, the resulting compound of formula la or lb is not racemic.

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Compounds of formula lc or ld can be converted to compounds of formula la or lb by treatment with a strong base such as lithium diisopropylamide in a suitable solvent such as THF in the presence or absence of HMPA at -78°C, followed by the addition of an alkylating agent R-R₁₇, or an acylating agent such as R-C(O)O-alkyl or R-C(O)Cl, wherein R is as defined above, except that R is not hydrogen, and R₁₇ is a leaving group such as bromo or iodo.

Method B':

Trans compounds of formula Id can be converted to the corresponding cis compounds of formula lc by using Method B, above, but using a proton source such as acetic acid in place of the alkylating agent.

15 Method C:

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Trans compounds of formula Id, wherein R is hydrogen and A, D and R4 are as defined above can be prepared by treating cis compounds of formula Ic with a strong base such as lithium diisopropylamide or potassium t-butoxide in a suitable solvent such as THF. Those skilled in the art will appreciate that since the reaction conditions of Method C can be similar to those of Method A, the conversion of cis to trans sometimes occurs in situ under the conditions of Method A.

Method D

Step D5

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Step D6

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In step D1 of Method D, the carboxylic acid XIII is treated with a chlorinating agent, e.g., thionyl chloride or oxalyl chloride, under a dry atmosphere, neat or in a suitable inert organic solvent, e.g., toluene, at 70°C to produce compound XIV.

In step D2, compound XV is converted to compound XVI in a two step reaction, first by deprotonating with a strong base, such as an alkyllithium, e.g., n-butyllithium, or metal hydride, e.g., sodium hydride, or a tertiary amine base, such triethylamine, in a suitable anhydrous organic solvent, e.g., dry THF, under a dry, inert atmosphere, e.g., nitrogen, at about 0°C to about -85°C, preferably about -78°C, over a period of about 30 to about 90 minutes, preferably about 60 minutes, and second by reacting the resulting anion, without isolation, with compound XIV in a suitable anhydrous organic solvent, e.g., dry THF, under a dry, inert atmosphere, e.g., nitrogen, at about -50°C to about -85°C, preferably about -78°C, over a period of about 30 to about 60 minutes, preferably about 45 minutes, followed by continued reaction at about -10°C to about 10°C, preferably about 0°C, for a period of about 30 to about 90 minutes, preferably about 60 minutes, then isolating the product, compound XVI, by extraction.

In step D3, compound XVI is treated with a dialkylboron triflate, e.g., di-n-butylborontriflate (Bu₂BSO₃CF₃), in a suitable inert organic solvent, e.g. CH₂Cl₂, under a dry, inert atmosphere, e.g., nitrogen, at about -60°C to about 10°C, preferably about -10°C to about 0°C, for a period of about 10 minutes. A tertiary amine base, e.g., diisopropylethylamine, is added at about -10°C to about 0°C, preferably

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about -6°C to about-3°C, for about 20 to about 40 minutes, preferably about 30 minutes. The mixture is stirred at about -50°C to about -85°C, preferably about -78°C, for about 20 to about 40 minutes, preferably about 30 minutes, then treated with compound XVII, at about -50°C to about -85°C, preferably about -78°C, for about 20 to about 40 minutes, preferably about 30 minutes. The mixture is stirred at about -10°C to about 5°C, preferably about 0°C for about 30 to about 90 minutes, preferably about 60 minutes, then quenched with an aqueous pH 7 buffer solution, e.g., an aqueous solution of KH₂PO₄ and NaOH, and treated with methanol, and hydrogen peroxide, preferably 30% hydrogen peroxide, at about -5°C to about 5°C, preferably about 0°C, for about 1 hour. The product is isolated by extraction and crystallized from a suitable solvent, e.g., hexane/ethyl acetate, to obtain compound XVIII.

Alternatively, step D3 comprises treating compound XVI with titanium tetrachloride (TiCl₄), in a suitable inert organic solvent, e.g. 15 CH₂Cl₂, at about -60°C to about 0°C, preferably about -25°C to about -15°C, and most preferably at about -20°C, for a period of about 10 minutes. Tetramethylethylenediamine (TMEDA) or a combination of TMEDA and triethylamine is added slowly over a period of about 10 minutes, while maintaining the temperature at about about -25°C to 20 about -10°C. The mixture is stirred at about -25°C to about -10°C, preferably about -15°C to about -10°C, for a period of 30 to 90 minutes, preferably about 60 minutes, then treated with a compound of the formula XVII. The mixture is stirred at about -25°C to about -10°C, preferably about -15°C to about -10°C, for a period of 30 to 90 minutes, 25 preferably about 60 minutes, then stirred for 30 to 60 minutes, preferably about 40 minutes, while warming to about 0°C to about 10°C, preferably about 10°C. The mixture is quenched with an aqueous solution of tartaric acid, preferably a solution of about 10% tartaric acid in water. The product is then isolated by extraction with a suitable solvent, e.g. 30 ethyl acetate, and recrystallized from a suitable solvent, such as ethyl actetate/hexane, to obtain compound XVIII.

In step D4, compound XVIII is treated with hydrogen peroxide, preferably 30% hydrogen peroxide, in a inert organic solvent,

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e.g., THF/ water, at about -5°C to about 5°C, preferably about 0°C, for about 10 to about 20 minutes, preferably about 15 minutes, then treated with a base, e.g., lithium hydroxide, at about -5°C to about 5°C, preferably about 0°C, until no starting material remains, as determined by thin layer chromatography (TLC), in about 2 hours to about 4 hours, preferably about 3 hours. The excess peracid is reduced by slowly adding a solution of sodium sulfite in water to the mixture over a period of about 30 to about 90 minutes, preferably about 70 minutes. The bulk of the solvent is removed under vacuum and the residue diluted with water. Compound IV is recovered from the mixture by extraction with a suitable inert organic solvent, e.g., toluene. The remaining aqueous solution is acidified to a pH of about 2.0 to about 3.0, preferably pH of about 2.4, using hydrochloric acid. The product is isolated by extraction using a suitable inert organic solvent, e.g., ethyl acetate, to provide compound XIX.

In step D5, compound XIX is reacted with compound XX, a dehydrative coupling agent, e.g., dicyclohexylcarbodiimide (DCC), and an activating agent, e.g., 1-hydroxybenzotriazole (HOBT), in a suitable inert organic solvent, e.g., dimethylformamide or acetonitrile, at about 25°C to about 50°C, preferably about 40°C. The reaction is continued until the starting material is consumed, as determined by TLC, in about 4 hours. The product is isolated by extraction to obtain compound XXI.

In step D6, compound XXI is cyclized by treating with triphenylphosphine or preferably a trialkylphosphine, e.g., tri-n-butylphosphine, and a dialkylazodicarboxylate, e.g., diethylazodicarboxylate (DEAD), in a suitable anhydrous organic solvent, e.g., dry THF, under a dry, inert atmosphere, e.g. nitrogen, at about -50°C to about -85°C, preferably about -70°C, for about 1 to about 3 hours, preferably about 2 hours. The reaction is then continued at about room temperature for about 12 to about 24 hours. The product is purified by preparative high performance liquid chromatography (HPLC) to obtain a compound of formula I, having trans relative stereochemistry. The use of tributylphosphine in this step gives reaction yields significantly higher than the yields obtained using triphenylphosphine.

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Alternatively, step D6 comprises combining compound XXI and a suitable phase transfer catalyst, e.g. tetra-n-butylammonium hydrogen sulfate, in a suitable solvent, such as methylene chloride. The mixture is stirred while cooling to about 0°C to 20°C, preferably about 10°C to about 20°C, then treated with an aqueous base, such as an alkali metal hydroxide, preferably 50% aqueous sodium hydroxide. A di- or tri-chlorobenzoyl chloride, preferably 2,6-dichlorobenzoyl chloride or 2,4,6-trichlorobenzoyl chloride, is slowly added over a period of 20 to 60 minutes, preferably about 30 minutes. The mixture is stirred at about 0°C to about 25°C, preferably about 15°C to about 20°C, for a period of 2 to 4 hours, preferably about 3 hours, then poured into cold water. The organic layer is separated and washed with water to neutral pH. The dior tri-chlorobenzoate product is isolated by crystallization from methylene chloride/heptane. The di- or tri-chlorobenzoate product is combined with a suitable phase transfer catalyst, e.g benzyltriethylammonium chloride, in a suitable solvent, such as a mixture methylene chloride and methyl t-butyl ether. The mixture is stirred at about 0°C to about 25°C, preferably about 15°C to about 20°C, and treated with an aqueous base, e.g. an alkali metal hydroxide, preferably 50% aqueous sodium hydroxide. After stirring for a period of 2 to 6 hours, preferably about 4 hours, the mixture is poured into ice water. The organic layer is washed with water to neutral pH. The product is isolated by removing the solvent, then purified by chromatography and recrystallization from a suitable solvent to give a compound of formula I, having trans relative stereochemistry.

A third alternative for step D6 comprises treating compound XXI in a suitable solvent, such as CH₂Cl₂, with a dialkylchlorophosphate, preferably diethylchlorophosphate, and an aqueous base, such as an alkali metal hydroxide, preferably 50% aqueous sodium hydroxide, in the presence of phase transfer catalyst, such as tetra-n-butylammonium hydrogen sulfate or benzyltriethylammonium chloride.

Another alternative for step D6 comprises treating compound XXI with a di- or tri-chlorobenzoyl chloride, preferably 2,6-

dichlorobenzoyl chloride or 2,4,6-trichlorobenzoyl chloride, and a suitable base, such as sodium hydride in a suitable solvent, such as CH_2Cl_2 , dimethylformamide, or a combination thereof. The product is isolated and purified by chromatography followed by crystallization from a suitable solvent, e.g. ether/hexane.

Starting compounds XIII, XV, XVII, and XX are all either commercially available or well known in the art and can be prepared via known methods.

Method E:

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Compounds of formula Ia can also be prepared by treatment of an imine of formula IV with an activated carboxylic acid derivative of formula XII in the presence of a base such as triethylamine, tributylamine or diethylisopropylamine in an inert solvent such as CH₂Cl₂, heptane or toluene. Examples of activated carboxylic acid derivatives of formula XII include acid chlorides (L=Cl), mixed anhydrides formed with phenyl phosphorodichloridate (L=OP(O)(Cl)OPh), and N-methylpyridinium esters formed from the reaction of an acid with N-methyl-2-chloropyridinium iodide (L=2-oxy-N-methylpyridinium iodide).

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Starting materials of formulae IV and V are known or can be prepared by methods well known in the art.

Method F:

A-CH=N-R⁴

$$TiCl_4$$

$$R^6$$

$$R^7$$

$$TMEDA$$

$$R^7$$

$$R^8$$

$$R^7$$

$$R^8$$

$$R^7$$

$$R^8$$

$$R^7$$

$$R^8$$

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Step F2

NaN
$$Si(CH_3)_3$$

NaN $Si(CH_3)_3$

NaN $Si(CH_3)_3$

NaN R^4

In step F1, compound XVI (from Method D, step 2) is dissolved in a suitable solvent, e.g. methylene chloride, then treated with titanium tetrachloride at about -60°C to about 0°C, preferably about -25°C to about -15°C, under a dry, inert atmosphere, preferably nitrogen, for a period of about 5 min. TMEDA is added and the mixture stirred at about -60°C to about -10°C, preferably about -25°C to about -20°C, for a period of about 1 hour. The imine (A-CH=N-R4) is slowly over a period of 20 to 40 min., preferably about 30 min., and the mixture is stirred at about -60°C to about 0°C, preferably about -25°C to about -15°C, for 20 to 40 min., preferably about 30 min. The mixture is then warmed to about 0°C and the reaction monitored by high pressure liquid chromatography (HPLC) until complete. The mixture is then poured into a solution of tartaric acid in water, preferably 10% tartaric acid. The product is isolated by extraction with a suitable solvent, e.g. ethyl acetate, then purified by crystallization.

In step F2, the product of step F1 is treated with a strong non-nucleophilic base, such as sodium or lithium bistrimethylsilylamide, in a suitable inert organic solvent, e.g. CH₂Cl₂, at about -20°C to about 10°C, preferably about 0°C. The mixture is stirred while gradually warming to about 20° to about 25°C, then monitored by HPLC until the starting material is gone, typically after a period of 1 to 2 hours. The reaction mixture is poured into aqueous tartaric acid, preferably 10% tartaric acid, and the product isolated from the organic layer.

Imines of the formula A-CH=N-R⁴ can be prepared from aldehydes of the formula A-CHO and amines of the formula R⁴-NH₂ by procedures well known in the art. Aldehydes of formula A-CHO and amines of formula R⁴-NH₂ are commercially available or can be prepared via known procedures.

Compounds of formula II can be prepared by methods similar to those described for compounds of formula I.

It will also be apparent to those skilled in the art, and by reference to the examples which follow, that compounds of formulae I and II can be converted into different compounds of formula I or II by well known methods. For example, a compound of formula I wherein A comprises a double or triple bond, or a compound of formula II wherein G comprises a double or triple bond can be converted to the corresponding saturated compound by treatment with hydrogen gas in the presence of a catalyst such as palladium or platinum on carbon.

Reactive groups not involved in the above processes can be protected during the reactions with conventional protecting groups which can be removed by standard procedures after the reaction. The following Table 3 shows some typical protecting groups:

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Group to be Protected	Table 3 Group to be Protected and Protecting Group
— СООН	-COOalkyl, -COObenzyl, -COOphenyl
> _{NH}	NCOalkyl, NCObenzyl, NCOphenyl,
	NCH ₂ OCH ₂ CH ₂ Si(CH ₃) ₃ , NC(O)OC(CH ₃) ₃ ,
	N-benzyl, NSi(CH ₃) ₃ , NSi-C(CH) ₃
•	O CH ₃
-NH ₂	-N
	Ö CH₃
—ОН	$-OCH_3$, $-OSi(CH_3)_3$, $-OSi-C(CH)_3$

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We have found that the compounds of this invention lower serum lipid levels, in particular serum cholesterol levels. Compounds of this invention have been found to inhibit the intestinal absorbtion of cholesterol and to significantly reduce the formation of liver cholesteryl esters in animal models. Some compounds also inhibit ACAT in vitro. Thus, compounds of this invention are hypocholesterolemic agents by virtue of their ability to inhibit the esterification and/or intestinal absorption of cholesterol; they are therefore useful in the treatment and prevention of atherosclerosis in mammals, in particular in humans.

In addition to the compound aspect, the present invention therefore also relates to a method of lowering serum cholesterol levels, which method comprises administering to a mammal in need of such treatment a hypocholesterolemic effective amount of a compound of formula I or II of this invention. The compound is preferably administered in a pharmaceutically acceptable carrier suitable for oral administration.

The <u>in vitro</u> and <u>in vivo</u> activity of the compounds of formulae I or II can be determined by the following procedures.

ACAT Assav (in vitro)

This assay measures the activity of ACAT by measuring the ACAT-mediated transfer of tritiated oleic acid from acyl-CoA to cholesterol to give labelled cholesteryl oleate. Rat liver microsomes are used as the source of ACAT. Assays are performed in round bottom microtiterplates using a total incubation volume of 50 μL . Each incubation well receives 10 μL assay buffer (0.5M KHPO4, 10 μM dithiothreitol, pH 7.4), 7.5 μL of 40 mg/mL BSA (Bovine Serum Albumin) and 12.5 μg of microsomal protein. The test compound (in sufficient amount to bring the final concentration to from 0.1 to 25 μM), reference compound, or vehicle control is added and the final volume brought to 47 μL . The microtiterplate is then floated on the surface of a 37°C water bath for fifteen minutes. Incubations are started by the addition of 3 μL 3H-acyl CoA (1 $\mu Ci/well$, final concentration of 10 μM acyl CoA). The plate is then returned to the water bath for 15 minutes. The incubations are then terminated by application of 15 μL from each incubation to

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Standards are applied to several lanes so that the cholesteryl ester band can be identified. After drying, the plates are eluted with 90:10:1 petroleum ether:diethyl ether:acetic acid. The standards are visualized via iodine vapor, and the regions corresponding to cholesteryl ester are scraped into 7 mL scintillation vials. 4 mL of scintillant are added to each vial, and the radioactivity quantified. Background count is determined by the boiled controls. Full activity is determined by activity in the presence of vehicle. The percent inhibition is calculated by subtracting the background from both control and test samples, and the test value is calculated as a percentage of the control. For IC50 determinations, the inhibition is plotted against drug does on a log scale and the concentration at which 50% inhibition is obtained is determined.

15 <u>In Vivo Assay of Hypolipidemic Agents Using the Hyperlipidemic</u> Hamster

Hamsters are separated into groups of six and given a controlled cholesterol diet (Purina Chow #5001 containing 0.5% cholesterol) for seven days. Diet consumption is monitored to determine dietary cholesterol exposure in the face of test compounds. The animals are dosed with the test compound once daily beginning with the initiation of diet. Dosing is by oral gavage of 0.2mL of corn oil alone (control group) or solution (or suspension) of test compound in corn oil. All animals moribund or in poor physical condition are euthanized. After seven days, the animals are anesthetized by IM injection of ketamine and sacrificed by decapitation. Blood is collected into vacutainer tubes containing EDTA for plasma lipid analysis and the liver excised for tissue lipid analysis. Data is reported as percent reduction of lipid versus control.

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The present invention also relates to a pharmaceutical composition comprising a compound of formula I or II of this invention and a pharmaceutically acceptable carrier. The compounds of formula I or II can be administered in any conventional oral dosage form such as

capsules, tablets, powders, cachets, suspensions or solutions. The formulations and pharmaceutical compositions can be prepared using conventional pharmaceutically acceptable excipients and additives and conventional techniques. Such pharmaceutically acceptable excipients and additives include non-toxic compatible fillers, binders, disintegrants, buffers, preservatives, anti-oxidants, lubricants, flavorings, thickeners, coloring agents, emulsifiers and the like.

The daily hypocholesteremic dose of a compound of formula I or II is about 7 to about 30 mg/kg of body weight per day. For an average body weight of 70kg, the dosage level is therefore from about 500 to about 2000 mg of drug per day, given in a single dose or 2-4 divided doses. The exact dose, however, is determined by the attending clinician and is dependent on the potency of the compound administered, the age, weight, condition and response of the patient.

Following are examples of preparing compounds of formulae I and II. The stereochemistry listed is relative stereochemistry unless otherwise noted. The terms cis/trans refer to the relative orientations at the beta-lactam 3- and 4- positions when each is monosubstituted (i.e., R=H).

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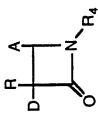
15

Freshly prepare lithium diisopropyl amide (LDA) by dissolving 23.96mL (17.39g, 172mmol) diisopropylamine in 230mL dry THF at -78°C under nitrogen. Add 103.9mL (166 mmol @ 1.6M in hexanes) of *n*-butyl lithium and stir at -78°C for 1h. To this cold solution add 32.58g (158mmol) of 5-phenyl valeric acid ethyl ester in 195mL dry THF over ~1h, keeping the reaction temperature below -65°C. Stir for 1h at -78°C, then add 38.13g (158mmol) of 4-methoxybenzylidine

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anisidine in 350mL dry CH_2Cl_2 . Allow the reaction to slowly come to room temperature and the precipitate that forms will begin to go into solution. Stir the reaction mixture for 16h at room temperature. Partition the mixture between 1.2liter of 1N aqueous hydrochloric acid (HCl) and 1liter of ether. Wash the ether layer with 300 mL 1N HCl. Combine the acid layers and extract with 1 liter of ether. Combine the ether extracts, dry over MgSO₄ and concentrate in vacuo. Crystallize the residue (35.08g, 55%) from ~200mL ethyl acetate-hexane (1:1) to give 32.05g of the title racemic compound as an off-white crystal, mp = 90-93°C.

Using a similar procedure, the following compounds shown in Tables 4 and 4A can also be prepared:



				Relative		
Ę.	۵	Œ	V	Stereo-	R ₄	Data
				chemistry		
1A	C ₆ H ₅ -CH ₂ C(O)-	C ₆ H ₅ -	C ₆ H ₅ -	3R,4S	p-MeO-C ₆ H ₄ -	mp=120.5-122.0°C
18	C ₆ H ₅ -(CH ₂) ₃ -	Н	C ₆ H ₅ -	3R,4R	p-MeO-C ₆ H ₄ -	mp=120.5-121.5°C
10	C ₆ H ₅ -(CH ₂) ₃ -	Н	C ₆ H ₅ -	3S,4R	p-MeO-C ₆ H ₄ -	mp=92.0-92.5°C
10	C ₆ H ₅ -(CH ₂) ₂ -	Н	C ₆ H ₅ -	35,45	p-MeO-C ₆ H ₄ -	mp=151-152°C
= =	C ₆ H ₅ -(CH ₂) ₂ -	Н	C ₆ H ₅ -	3S,4R	p-MeO-C ₆ H ₄ -	mp=156-158°C
#	C ₆ H ₅ -(CH ₂) ₃ -	н	C ₆ H ₅ -	4:1 cis to	2,4,6-tri-MeO-	CI MS: (M+1)432
				trans	C ₆ H ₄ -	
15	C ₆ H ₅ -(CH ₂) ₃ -	Н	p-NO ₂ -C ₆ H ₄ -	3S,4R	p-MeO-C ₆ H ₄ -	mp=116-117°C
Ŧ	C ₆ H ₅ -(CH ₂) ₃ -	Н	p-NO2-C ₆ H ₄ -	3R,4R	p-MeO-C ₆ H ₄ -	mp=120.5-122.0°C
11	C ₆ H ₅ -(CH ₂) ₃ -	СН3СН2-	-C ₆ H ₅ CH=CH-	38,48	2,4,6-tri-MeO-	FAB MS: (M+1)486.2
					C ₆ H₄-	
1.	C ₆ H ₅ -(CH ₂) ₃ -	CH ₃ CH ₂ -	CH ₃ CH ₂ - C ₆ H ₅ -CH=CH-	3R,4S	2,4,6-tri-MeO-	FAB MS: (M+1)486.2
					C ₆ H ₄ -	

1L CeH	C ₆ H ₅ -(CH ₂) ₃ -	I	C ₆ H ₅ -CH=CH-	3S,4S	p-MeO-C ₆ H ₄ -	mp=119.5-120.5°C
Τ	C ₆ H ₅ -(CH ₂) ₃ -	Ŧ	p-OH-C ₆ H ₄ -	38,48	p-MeO-C ₆ H ₄ -	mp=152.5-155.0°C
_	C ₆ H ₅ -(CH ₂) ₃ -	I	p-MeO-C ₆ H ₄ -	38,48	p-MeO-C ₆ H ₄ -	mp=86-88°C
		-	CH=CH-			
1P C ₆ H	C ₆ H ₅ -(CH ₂) ₃ -	Ξ	3-MeO-C ₆ H ₄ -	35,48	p-MeO-C ₆ H ₄ -	mp=90.5-91.0°C
5	C ₆ H ₅ -(CH ₂) ₃ -	I	p-MeO-C ₆ H ₄ -	trans	3-pyridyl-	1H NMR (CDC13) 8 8.41
						(s,1H), 8.28(s, 1H), 7.79(d,
						1H), 7.20(m, 8H), 6.90(d,
						2H), 4.63(s, 1H), 3.80(s, 3H),
						3.20(t, 1H), 1.85(m, 4H)
1AN Cel	C ₆ H ₅ -(CH ₂) ₃ -	I	p-MeO-C ₆ H ₄ -	trans	p-CF ₃ O-C ₆ H ₄ -	p-CF3O-C6H4- elemental analysis: calc'd
	•					C=68.56, H=5.31, N=3.08;
						found C=68.32, H=5.12,
						N=2.97
1AO Ce	C ₆ H ₅ -(CH ₂) ₃ -	I	4-MeO-C ₆ H ₄ -	cis	p-CI-C ₆ H ₄ -	elemental analysis: calc'd
						C=73.97, H=5.96, N=3.45,
						Cl=8.73; found C=73.63,
						H=5.92, N=3.52, Cl=9.12

1AP	C ₆ H ₅ -(CH ₂) ₃ -	H	4-MeO-C ₆ H ₄ -	cis	p-CH ₃ -C ₆ H ₄ -	elemental analysis: calc'd
						C=81.01, H=7.06, N=3.63;
						found C=80.97, H=7.06,
						N=3.74
1 A Q	C ₆ H ₅ -(CH ₂) ₃ -	H	4-CH ₃ O-C ₆ H ₄ -	cis	p-C ₆ H ₅ O-	elemental analysis: calc'd
					C ₆ H ₄ -	C=80.32, H=6.31, N=3.02;
			•			found C=80.26, H=6.27,
						N=3.18
1AR	C ₆ H ₅ -(CH ₂) ₃ -	H	N	trans	p-CH ₃ O-C ₆ H ₄ -	mp=101.5-102.5°C
1AS	C ₆ H ₅ -(CH ₂) ₃ -	Ħ	(CH ₃) ₃ CSi(CH ₃) ₂ -	trans	p-CH ₃ O-C ₆ H ₄ -	EIMS (M+1)=516
			OCH ₂ -C ₆ H ₄ -			
1AT	C ₆ H ₅ -(CH ₂) ₃ -	н	(CH ₃) ₃ CSi(CH ₃) ₂ -	cis	p-CH ₃ O-C ₆ H ₄ - mp=84-85°C	mp=84-85°C
			OCH ₂ -C ₆ H ₄ -			
1AU	C ₆ H ₅ -(CH ₂) ₃ -	Н	4-CH ₃ S-C ₆ H ₄ -	cis	p-CH ₃ O-C ₆ H;-	p-CH ₃ O-C ₆ H ₄ - mp=103-104°C
1 A V		H		trans	p-CH ₃ O-C ₆ H ₄ -	FABMS (M+1)=492
			CH ₂ O(CH ₂) ₂ Si(CH ₃) ₃			
1AW	C ₆ H ₅ -(CH ₂) ₃ -	Ŧ	Pz z	cis	p-CH ₃ O-C ₆ H ₄ -	mp=108.5-110°C
			CH ₂ O(CH ₂) ₂ Si(CH ₃) ₃			

1AX	1AX C ₆ H ₅ -(CH ₂) ₃ -	I			p-CH ₃ O-C ₆ H ₄ - EIMS (M)=443	:IMS (M)=443
1AY	C ₆ H ₅ -(CH ₂) ₃ -	I	4-((CH ₃) ₂ CH-O)-	cis	p-CH ₃ O-C ₆ H ₄ - I	mp=96-97°C
1AZ	C ₆ H ₅ -(CH ₂)3-	I	4-(CH ₃ (CH) ₂ -O)- C ₆ H ₄ -	cis	p-CH ₃ O-C ₆ H ₄ -	mp=96-97°C
1BA	C ₆ H ₅ -(CH ₂) ₃ -	I	CH30 CH3	cls	p-CH ₃ O-C ₆ H ₄ -	p-CH ₃ O-C ₆ H ₄ - mp=91.5-92.5°C
188	C ₆ H ₅ -(CH ₂) ₃ -	I	SHOO CH3	cis	p-CH ₃ O-C ₆ H ₄ -	mp=86.0-87.0°C
1BC	C ₆ H ₅ -(CH ₂) ₃ -	I	C	cis	p-CH ₃ O-C ₆ H ₄ -	mp=130.0-131.0°C
180	C ₆ H ₅ -(CH ₂) ₃ -	I	C	trans	p-CH ₃ O-C ₆ H ₄ -	mp=111.0-112.5°C
1BE	C ₆ H ₅ -(CH ₂) ₃ -	I	P	cis	p-CH ₃ O-C ₆ H ₄ -	mp=74.5-75ºC
18F	C ₆ H ₅ -(CH ₂) ₃ -	王	Ç	trans	p-CH ₃ O-C ₆ H ₄ -	p-CH ₃ O-C ₆ H ₄ - mp=79.5-80.5°C
186	C ₆ H ₅ -(CH ₂) ₃ -	I	4-CF ₃ -C ₆ H ₄ -	trans	p-CH ₃ O-C ₆ H ₄ -	p-CH ₃ O-C ₆ H ₄ - mp=94.5-96.0°C
田田	+	I	4-CF3-C ₆ H ₄ -	cls	p-CH ₃ O-C ₆ H ₄ -	p-CH ₃ O-C ₆ H ₄ - mp=114.0-115.5°C

						00007 177
181	C ₆ H ₅ -(CH ₂) ₃ -	 I		cis	p-CH ₃ O-C ₆ H ₄ - mp=117-120°C	mp=11/-1z0
187	C ₆ H ₅ -(CH ₂) ₃ -	エ	S	cis	p-CH ₃ O-C ₆ H ₄ -	mp=88.5-90.5°C
70,	C-Us (CHo)os	I	3-CF ₃ O-C ₆ H ₄ -	cis	p-CH ₃ O-C ₆ H ₄ -	p-CH ₃ O-C ₆ H ₄ - mp=66.0-68.0°C
—	CeHs-(CHs)s-	I	3-CF ₃ O-C ₆ H ₄ -	trans	p-CH ₃ O-C ₆ H ₄ -	p-CH ₃ O-C ₆ H ₄ - CI MS (M+1)=456.2
1 BM	CeHr-(CH2)3-	I	4-CH ₃ -C ₆ H ₄ -	cis	p-CH ₃ O-C ₆ H ₄ - mp=124-125°C	mp=124-125°C
1BN	C ₆ H ₅ -(CH ₂) ₃ -	エ	4-(C ₆ H ₅ -CH ₂ -O)-	cis	p-CH ₃ O-C ₆ H ₄ - mp=131-132°C	mp=131-132°C
			C6H4-			04 0E0C
180	C ₆ H ₅ -(CH ₂) ₃ -	I	CH3CH2-O-CeH4-	cis	p-CH3O-C6H4-	mp=64-63-0
1BP	C ₆ H ₅ -(CH ₂) ₃ -	ェ		trans	p-CH ₃ O-C ₆ H ₄ -	mp=68-70°C
180	C ₆ H ₅ -(CH ₂) ₃ -	ェ	C	trans	p-CH ₃ O-C ₆ H ₄ - mp=50-52°C	mp=50-52°C
			0			703 02 0 72
- ABB	CeHs-(CH2)3-	Ξ	CH ₃ (CH ₂) ₃ -O-C ₆ H ₄ -	cis	p-CH ₃ O-C ₆ H ₄ -	mp=/1.0-/2.5
100	+-	I	4-(C ₆ H ₅ -O)-C ₆ H ₄ -	cis	p-CH ₃ O-C ₆ H ₄ -	p-CH ₃ O-C ₆ H ₄ - mp=108-109°C
	+-	I	4-(C ₆ H ₅)-C ₆ H ₄ -	cis	p-CH ₃ O-C ₆ H ₄ -	mp=127.5-128.5°C
1BU	C ₆ H ₅ -(CH ₂) ₃ -	I	4-(CH2=CH-CH2-O)-	cis	p-CH ₃ O-C ₆ H ₄ -	mp=77.0-77.5°C
		,	C ₆ H ₄ -			

187	C ₆ H ₅ -(CH ₂) ₃ -	I	OCH3	cis	p-CH ₃ O-C ₆ H ₄ - mp=116-117°C	mp=116-117°C
1BW	C ₆ H ₅ -(CH ₂)3-	I	cho.	cis	p-CH ₃ O-C ₆ H ₄ -	mp=129.5-130.5°C
1BX	C ₆ H ₅ -(CH ₂) ₃ -	I		cis	p-CH ₃ O-C ₆ H ₄ -	p-CH ₃ O-C ₆ H ₄ - mp=170.0-170.5°C
1BY	C ₆ H ₅ -(CH ₂) ₃ -	Ξ	4-(CH3CH2-O)-C6H4-	cis	C ₆ H ₅ -	mp=89.5-90.0°C
182	C ₆ H ₅ -(CH ₂) ₃ -	I		cis	p-CH ₃ O-C ₆ H ₄ -	mp=100-104°C
1CA	C ₆ H ₅ -(CH ₂) ₃ -	I		trans	4-CH ₃ O-C ₆ H ₄ - mp=91-92°C	mp=91-92°C
1CB	C ₆ H ₅ -(CH ₂) ₃ -	I	4-CH ₃ O-C ₆ H ₄ -	cis	(CH3)3CSI(CH3)2-	mp=93-94°C
					O-C6H4-	
100	C ₆ H ₅ -(CH ₂) ₂ -	н	4-CH ₃ O-C ₆ H ₄ -	cis	4-CH ₃ O-C ₆ H ₄ -	mp=128-129°C
1CD	C ₆ H ₅ -O-(CH ₂) ₂ -	H	4-CH ₃ O-C ₆ H ₄ -	cis	4-CH ₃ O-C ₆ H ₄ -	4-CH ₃ O-C ₆ H ₄ - mp=120-121°C
1 2	C ₆ H ₅ -(CH ₂) ₆ -	н	4-CH ₃ O-C ₆ H ₄ -	cis	4-CH ₃ O-C ₆ H ₄ - mp=80-81°C	mp=80-81°C
1CF	(CH ₂)3-	H	4-CH ₃ O-C ₆ H ₄ -	cis	4-CH ₃ O-C ₆ H ₄ -	4-CH ₃ O-C ₆ H ₄ - mp=101-102°C

	<u></u>			70				9	<u></u>				O		
4-CH3O-C6H4- elemental analysis: calc'd	C=71.25, H=5.74, N=3.32;	found C=71.34, H=5.73,	N=3.43	elemental analysis: calc'd	C=73.64, H=5.67, N=3.;	found C=73.39, H=5.51,	N=3.54	4-CH3O-C6H4- elemental analysis: calc'd	C=78.04, H=7.03, N=3.37;	found C=77.69, H=6.98,	N=3.60	4-CH ₃ O-C ₆ H ₄ - mp=104-105.5 ^o C	mp=144.0-144.5°C	mp=92-94°C	
4-CH ₃ O-C ₆ H ₄ -				C ₆ H ₅ -				4-CH ₃ O-C ₆ H ₄ -				4-CH ₃ O-C ₆ H ₄ -	4-CH ₃ O-C ₆ H ₄ -	4-CH ₃ O-C ₆ H ₄ - mp=92-94°C	_
cis				cis				cis				trans	cis	cis	
4-CH ₃ O-C ₆ H ₄ -				4-CH ₃ O-C ₆ H ₄ -				4-CH ₃ O-C ₆ H ₄ -				4-CH ₃ S-C ₆ H ₄ -		4-((CH ₃) ₂ N-(CH ₂) ₃ -0)-	CeH4.
I				ī				I				Ξ	I	I	
4-F-C6H4-O-(CH2)2-				4-F-C6H4-O-(CH2)2-				C ₆ H ₅ -(CH ₂) ₄ -				1CM C ₆ H ₅ -(CH ₂) ₃ -	C ₆ H ₅ -(CH ₂) ₃ -	C ₆ H ₅ -(CH ₂) ₃ -	
100				1CH				101				1CM	1CN	5	

C ₆ H ₅ -(CH ₂)3-	Ξ	4-CH ₃ O-C ₆ H ₄ -	C ₆ H ₄ - cis	C ₆ H ₅ -	elemental analysis: calc'd C=80.83, H=6.78, N=3.77; found C=80.69, H=6.78, N=3.90
	R ₂₁ - E - L	z'	H ₂₈		·
				Rel. Stereo-	
п.,.п.	Ros-F-	R23-G-	H ₂₀	chemistry	Data
CapHot-	H	C ₆ H ₅ -	p-MeO-C ₆ H ₄ -	3H,4R	mp=176.0-177.0°C
C40H21-	I	C ₆ H ₅ -	p-MeO-C ₆ H ₄ -	3S,4R	mp=83.5-84.0°C
C10H21-	I	C ₆ H ₅ -	2,4,6-tri-MeO-	3R,4R	
120		•	C ₆ H ₄ -	3.6:1 cls/trans	
	CeHs-	C ₆ H ₅ -	p-MeO-C ₆ H ₄ -	3R,4S	mp=158.5-159.0°C
	i-Pr	C ₆ H ₅ -	p-MeO-C ₆ H ₄ -	3H,4H	mp=162-164°C
CoHr.CHo.	CeHs-	C ₆ H ₅ -	p-MeO-C ₆ H ₄ -	38,48	mp=185.0-186.0°C
210 6110	H-2	C.He.	p-MeO-CeH4-	3R,4S	mp=123.0-124.5°C

12	CH3CH2-	C ₆ H ₅ -	C ₆ H ₅ -	p-MeO-C ₆ H ₄ -	38,48	mp=101.0-102.5°C
1AA	СН3СН2-	C ₆ H ₅ -	C ₆ H ₅ -	p-MeO-C ₆ H ₄ -	3R,4S	mp=73.5-75.0°C
1AB	I	CH ₃ CH ₂ .	C ₆ H ₅ -	p-MeO-C ₆ H ₄ -	3R,4R	mp=134.0-135.5°C
1AC	1AC cyc-C ₅ H ₁₁	C ₆ H ₅ -	C ₆ H ₅ -	p-MeO-C ₆ H ₄ -	8:5 mix cis/trans	mp=57.5-62.5°C
					phenyl	
1AD	I	CH3CH2-	C ₆ H ₅ -	p-MeO-C ₆ H ₄ -	3R,4S	mp=107-109°C
1AE	I	CH ₃ CH ₂ -	C ₆ H ₅ -	2,4,6-tri-MeO-	3R,4R	CI MS: (M+1)342
				C ₆ H ₄ -		
1AF	I	CH ₃ CH ₂ .	C ₆ H ₅ -	p-MeO-C ₆ H ₄ -	3R,4S	FAB MS:(M+1)307.9
			CH=CH-			
1AG	I	CH ₃ CH ₂ .	C ₆ H ₅ -	p-MeO-C ₆ H ₄ -	38,48	mp=84-86°C
			CH=CH-			
1AH	I	СН3-	C ₆ H ₅ -	p-MeO-C ₆ H ₄ -	38,48	mp=122-123°C
14	Н	CH3-	C ₆ H ₅ -	p-MeO-C ₆ H ₄ -	3S,4R	mp=93-94°C
1 A J	I	снзснз-	p-N02-	p-MeO-C6H4-	3S,4R	mp=115-116 ⁰ C
			C ₆ H ₄ -			
1AK	I	снзсн2-	4-NO2-	4-MeO-C6H4-	3R,4R	mp=101-102 ^o C
			C ₆ H ₄ -			
1AL	Н	снзснз-	4-MeO-	4-MeO-C ₆ H4-	35,48	mp=96-103 ^o C
			C ₆ H ₄ -			

1CJ	1CJ (CH3)2-N-	I	4-MeO- C6H5-	C ₆ H ₅ -	cis	mp=115-1170C
1 0 1 0 1 0 0 1 0 0 1 0	1CK C6H5-	снзсн2-	4-MeO- CGH4-	13CH2- 4-MeO- 4-MeO-C6H4- C6H4-	trans	mp=56-58 ^o C
					•	
101	1C1 C10H21-	I	4-MeO-	4-MeO- 4-MeO-C6H4-	cis	elem. anal.: calc'd C=76.56, H=8.80,
<u>.</u>			C ₆ H ₄ -			N=3.31; found C=76.60, H=8.77,
						N=3.48

STEP 1: Add 39.1mL (117.2 mmol) of ethyl magnesium bromide to a 0°C solution of 31.00g (97.6 mmol) of (-)-10-(diisopropylsulfonamido)-isobomeol (See Oppolzer, et al, <u>Tet. Lett.. 25</u> (1984), p. 5885) in 370mL dry THF. Stir the mixture for 0.5h at 0°C, then at room temperature for 0.5h. Add 37.74mL (39.67g, 117.2mmol) of 5-phenylvaleric acid anhydride to this mixture at 0°C and stir overnight at room temperature. Pour the mixture into 1liter of half-saturated NaHCO₃ and extract with two-800mL portions of hexane. Dry the combined hexane layers with Na₂SO₄ and concentrate in vacuo. Chromatograph the residue (57.35g) in three portions over ~800g SiO₂ eluting with 2% ethyl acetate-CH₂Cl₂ to obtain the desired ester (42.07g, 90.2%), FAB MS: (M+1) 479.

STEP 2: Using a procedure similar to Example 1, treat the ester of Step 1, washing the ether layer with 200mL 1N aqueous HCl, drying with MgSO₄ and concentrating in vacuo. Chromatograph the residue over 1kg SiO₂, eluting with 20% ethyl acetate-hexane to give 24.19g (79%) of the recovered alcohol and 25.66 (66%) of the title enantiomerically enriched β-lactam. This lactam can be further enriched by chromatography over a ChiralcelTM OD column (Daicel Chemical Industries, Ltd., Fort Lee, NJ), eluting with 10% isopropanol-hexanes. Crystallize the resulting enantiomerically pure (3S,4S) compound from ether-hexane to obtain a white solid, mp = 84 - 85°C, [α]_D²⁵ = -98.0° (MeOH).

Using a similar procedure, the following enantiomerically pure (3R,4R) compound (EXAMPLE 2A) can also be prepared:

Ph(CH₂)₃, OCH₃

OCH₃

OCH₃

(m.p. = 84-85°C; FAB MS: (M+1) 402.2;
$$\left[\alpha\right]_{D}^{25} = +98.0^{\circ}$$
 (M

EXAMPLE 3

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Freshly prepare a solution of lithium isopropylcyclohexyl amide (LICA) by dissolving 0.68mL (0.58g, 4.11mmol) isopropylcyclohexyl amine in 20mL THF at -78°C under nitrogen. Add 2.58mL (4.03mmol) *n*-butyl lithium (1.6M, from Aldrich, Milwaukee, WI) and stir at -78°C for 1h. Add 1.04g (2.61mmol) of the compound of Example 1K in 5mL dry THF to the solution. After 2h at -78°C, add 2.8mL (2.89g, 16mmol) of hexamethylphosphoric triamide followed by 0.33mL (641mg, 4.11mmol) of ethyl iodide at -78°C. Stir the mixture overnight at room temperature. Quench the reaction with 40mL 1N aqueous HCl and extract with two-50mL portions of CH₂Cl₂. Combine the CH₂Cl₂ layers and wash sequentially with 50mL 1N aqueous HCl and 50mL Na₂SO₃. Dry over MgSO₄ and concentrate in vacuo. Chromatograph the residue over 40g SiO₂, eluting with 20% ethyl acetate-hexane to give 0.95g (83%) of the title compound as a colorless oil, FAB MS: (M+1) 426.4

Using a similar procedure, the following compounds shown in Tables 5 and 5Acan also be prepared:

			B 0	∢ —		
				N R4		
				Relative		
Ë.	٥	Œ	۷	Stereo-	R4	Data
				chemistry		
3A	C ₆ H ₅ -(CH ₂) ₃ -	CH3CH2-	C ₆ H ₅ -	3S,4S	p-MeO-C ₆ H ₄ -	mp=103.0-103.5°C
3B	C ₆ H ₅ -(CH ₂) ₃ -	C ₆ H ₅ -	C ₆ H ₅ -	3R,4S	p-MeO-C ₆ H ₄ -	FAB MS: (M+1) 448
3C	C ₆ H ₅ -(CH ₂) ₃ -	C10H21-	C ₆ H ₅ -	3S,4R	p-MeO-C ₆ H ₄ -	CI MS: (M+1) 512
3D	C ₆ H ₅ -(CH ₂) ₃ -	CH ₃ CH ₂ -	C ₆ H ₅ -	3S,4S	2,4,6-tri-MeO-	mp=145.5-147.0°C
					C ₆ H₄-	
3E	C ₆ H ₅ -(CH ₂) ₃ -	CH ₃ CH ₂ - C ₆ H ₅ -	C ₆ H ₅ -	3R,4S	p-MeO-C ₆ H ₄ -	mp=82.5-83.5°C
ЭЕ	C ₆ H ₅ -(CH ₂) ₃ -	СН3СН2-	C ₆ H ₅ -	3R,4S	2,4,6-tri-MeO-	mp=132-134°C
					C ₆ H ₄ -	
36	C ₆ H ₅ -(CH ₂) ₃ -	CH ₃ CH ₂ -	CH3CH2- C6H5-CH=CH-	38,48	p-MeO-C ₆ H ₄ -	2°66-99≡0m
3Н	C ₆ H ₅ -(CH ₂) ₂ -	CH ₃ CH ₂ -	C ₆ H ₅ -	3R,4S	p-MeO-C ₆ H ₄ -	mp=100.0-100.5°C
31	C ₆ H ₅ -(CH ₂) ₂ -	СН3-	C ₆ H ₅ -	3H,4S	p-MeO-C ₆ H ₄ -	mp=130-131°C

				Relative		
Ä.	۵	Œ	∢	Stereo-	R4	Data
				chemistry		
3)	C ₆ H ₅ -(CH ₂) ₃ -	СН3-	C ₆ H ₅ -	38,48	p-MeO-C ₆ H ₄ -	mp=88-89°C
ЭK	C ₆ H ₅ -(CH ₂) ₄ -	СН3-	C ₆ H ₅ -	38,48	p-MeO-C ₆ H ₄ -	mp=109-110°C
31	C ₆ H ₅ -(CH ₂) ₄ -	CH3CH2- C6H5-	C ₆ H ₅ -	3S,4S	p-MeO-C ₆ H ₄ -	mp=95-96°C
Ж	C ₆ H ₅ -(CH ₂) ₃ -	CH3CH2-	CH ₃ CH ₂ - p-MeO-C ₆ H ₄ -	3R,4S	p-MeO-C ₆ H ₄ -	FAB MS: (M+1) 430.4
NE.	C ₆ H ₅ -(CH ₂) ₃ -	C ₆ H ₄ -	C ₆ H ₅ -CH=CH-	racemic	p-MeO-C ₆ H ₄ -	FAB MS: (M+1) 516.4
		(CH ₂)3-				
ဓ္က	30 C ₆ H ₅ -(CH ₂)3-	CH3CH2-	CH ₃ CH ₂ - p-MeO-C ₆ H ₄ -	38,48	p-MeO-C ₆ H ₄ -	p-MeO-C ₆ H ₄ - FAB MS: (M+1) 430.4

		·	д - ц	a S		
			¹ 2 - E	, R ₂₀		
į	l S	Į.	1	Rel. Stereo-	(
Ľ.	H21-E-		H23-G-	cnemistry	H20	Data
စ္က	C10H21-	CH ₃ CH ₂ -	C ₆ H ₅ -	3S,4S	p-MeO-C ₆ H ₄ -	mp=47.5-48.5°C
38	C ₁₀ H ₂₁ -	C ₆ H ₅ -	C ₆ H ₅ -	3R,4S	p-MeO-C ₆ H ₄ -	mp=103.0-103.5°C
3Т	C10H21-	CH ₃ CH ₂ - C ₆ H ₅ -	C ₆ H ₅ -	3R,4R	p-MeO-C ₆ H ₄ -	mp=48.0-49.5°C
30	C10H21-	C ₆ H ₅ -	C ₆ H ₅ -	3R,4R	p-MeO-C ₆ H ₄ -	CI MS: (M+1) 512.6
		(CH ₂)3-				
3	C10H21-	СН3СН2-	C ₆ H ₅ -	3S,4R	2,4,6-tri-MeO- C ₈ H ₄ -	CI MS: (M+1) 482
3W	C ₁₀ H ₂₁ -	СН3СН2-	C ₆ H ₅ -	3R.4R	2,4,6-tri-MeO- CeHa-	2₀86-96=dш
3X	C10H21-	CH ₃ CH ₂ -	C ₆ H ₅ -CH=CH-	3S,4S	p-MeO-C ₆ H ₄ -	EI MS: (M+) 425
3⊀	C10H21-	СН3-	C ₆ H ₅ -	3S,4S	p-MeO-C ₆ H ₄ -	2°76-96=dm

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EXAMPLE 4

Add 100mg (0.30mmol) of the trans β -lactam of Example 1V in 2mL dry THF to a solution of 1.22mL (0.32mmol) LDA (1.5M, from Aldrich, Milwaukee, WI) in 0.5mL dry THF at 5 -78°C under nitrogen. Stir for 5min at -78°C, then quench at low temperature with ~0.3mL acetic acid. Partition the mixture between 30mL ethyl acetate and 20mL water. Wash the organic layer with 20 mL 10% aqueous NaHCO3 solution, dry over MgSO4 and concentrate in vacuo to give 98mg of an oily white solid. Chromatograph the residue 10 over SiO₂, eluting with 20% ethyl acetate-hexane to obtain 26 mg of the title cis β -lactam as a white solid, mp = 141.3 - 142.3°C.

EXAMPLE 5

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Dissolve 32.05g (79.8mmol) of the racemic cis β -lactam of Example 1 in 500mL of THF. Add 1.79g (16.0mmol) of potassium tbutoxide and stir at 0°C for 1.5h. Partition the reaction mixture between 600mL 1N aqueous HCl and 1.2 liters of ether. Extract the aqueous layer with 400mL of ether. Combine the ether layers, dry over MgSO4 and concentrate in vacuo to give 32.0g of a mixture of cis and trans β lactams (2.7:1). Isolate the pure trans β -lactam via silica gel HPLC

chromatography, eluting with 10% ethyl acetate-hexane. Crystallize from ethyl acetate-hexane to give white crystals, mp = 96.0 - 97.5°.

Using a procedure similar to that of Example 5, the following compounds shown in Tables 6 and 6A can be prepared:

	. Data	4-CH ₃ O-C ₆ H ₄ - FAB MS (M+1)=402.2	4-CH ₃ O-C ₆ H ₄ - mp=109.5-110.0°C	CIMS (M+1)=390	3-CH3O-C6H4- elemental analysis: calc'd	C=77.78, H=6.78, N=3.49; found	C=77.75, H=6.70, N=3.60	CIMS (M+1)=406	elemental analysis: catc'd	C=78.04, H=7.04, N=3.37; found	C=78.01, H=7.03, N=3.47
	R4	4-CH ₃ O-C ₆ H ₄ -	4-CH ₃ O-C ₆ H ₄ -	4-F-C ₆ H ₄ -	3-CH ₃ O-C ₆ H ₄ -			4-CI-C ₆ H ₄ -	4-(CH3CH2-O)-	C6H4-	
-	Relative Stereo- chemistry	3S,4R single enantiomer	3H,4S	trans	trans			trans	trans	_	
D A A O	A	4-CH ₃ O-C ₆ H ₄ -	3-CH ₃ O-C ₆ H ₄ -	4-CH ₃ O-C ₆ H ₄ -	4-CH ₃ O-C ₆ H ₄ -			4-CH ₃ O-C ₆ H ₄ -	4-CH ₃ O-C ₆ H ₄ -		
	Œ	Ι	エ	Н	I			H	I		
·	Q	C ₆ H ₅ -(CH ₂) ₃ -	C ₆ H ₅ -(CH ₂) ₃ -	C ₆ H ₅ -(CH ₂) ₃ -	C ₆ H ₅ -(CH ₂) ₃ -			C ₆ H ₅ -(CH ₂) ₃ -	C ₆ H ₅ -(CH ₂) ₃ -		
	Ex.	5B	2C	5D	SE			56	2H		

51	C ₆ H ₅ -(CH ₂) ₃ -	I	4-CH ₃ O-C ₆ H ₄ -	trans	4-CH ₃ S-C ₆ H ₄ -	4-CH ₃ S-C ₆ H ₄ - elemental analysis: calc'd
						C=74.79, H=6.52, N=3.35; found
						C=74.74, H=6.44, N=3.48
5J	C ₆ H ₅ -(CH ₂) ₃ -	н	4-CH ₃ O-C ₆ H ₄ -	trans	4-CH ₃ -C ₆ H ₄ -	elemental analysis: calc'd
						C=81.01, H=7.06, N=3.63; found
						C=81.25, H=7.09, N=3.75
5K	C ₆ H ₅ -(CH ₂) ₃ -	H	4-CH ₃ O-C ₆ H ₄ -	trans	4-(C ₆ H ₅ -O)-	elemental analysis: calc'd
					C ₆ H ₄ -	C=80.32, H=6.31, N=3.02; found
						C=80.36, H=6.29, N=3.16
56	() (CH ₂) ₃ 111	Н	HOO-	trans	C ₆ H ₅ -	mp=74-75°C
)	optically		$[\alpha]_{D}^{25} = -7.6^{\circ}$
				pure		
2M	() (CH ₂)3	I	() ocH ₃	trans	C ₆ H ₅ -	mp=74-75°C
)	optically		$[\alpha]_{D}^{25} = -7.5^{\circ}$
				pure		
5P	C ₆ H ₅ -(CH ₂) ₃ -	H	OCH ₃	trans	4-CH ₃ O-C ₆ H ₄ -	4-CH ₃ O-C ₆ H ₄ - mp=70.5-71.5°C
50	C ₆ H ₅ -(CH ₂) ₃ -	I		trans	4-CH ₃ O-C ₆ H ₄ -	4-CH ₃ O-C ₆ H ₄ - mp=79.5-81.0°C
			//			

5R	C ₆ H ₅ -(CH ₂) ₃ -	Н	4-CH ₃ -C ₆ H ₄ -	trans	4-CH3O-C6H4-	4-CH ₃ O-C ₆ H ₄ - m ₀₌₇₄ 5-77 0°C
58	C ₆ H ₅ -(CH ₂) ₃ -	H	4-(CH ₃ CH ₂ -O)-	trans	4-CH ₃ O-C ₆ H ₄ - mp=85-87°C	mp=85-87°C
			C ₆ H ₄ -		•	
5T	C ₆ H ₅ -(CH ₂) ₃ -	H	4-(C ₆ H ₅ -CH ₂ -O)-	trans	4-CH ₃ O-C ₆ H ₄ -	4-CH ₃ O-C ₆ H ₄ - mp=111-112°C
			C ₆ H ₄ -			-
20	C ₆ H ₅ -(CH ₂) ₃ -	I	4-(CH2=CH-CH2-O)-	trans	4-CH ₃ O-C ₆ H ₄ -	4-CH ₃ O-C ₆ H ₄ - mp=75.5-77.0°C
			C ₆ H ₄ -			
50	C ₆ H ₅ -(CH ₂) ₃ -	I	4-(C6H5-O)-C6H4-	trans	4-CH ₃ O-C ₆ H ₄ -	mp=103.5-105.5°C
5W	C ₆ H ₅ -(CH ₂) ₂ -	エ	4-CH ₃ O-C ₆ H ₄ -	trans	4-CH ₃ O-C ₆ H ₄ - m _{D=75-77°C}	mp=75-77°C
2X	C ₆ H ₅ -O-(CH ₂) ₂ -	I	4-CH ₃ O-C ₆ H ₄ -	trans	4-CH ₃ O-C ₆ H ₄ -	4-CH ₃ O-C ₆ H ₄ - mp=122-123°C
5∀	C ₆ H ₅ -(CH ₂) ₆ -	I	4-CH ₃ O-C ₆ H ₄ -	trans	4-CH ₃ O-C ₆ H ₄ -	elemental analysis: calc'd
						C=78.52, H=7.50, N=3.16; found
1						C=78.32, H=7.37, N=3.25
25	C6H5-(CH2)2-O-	Ξ	4-CH ₃ O-C ₆ H ₄ -	trans	4-CH ₃ O-C ₆ H ₄ -	4-CH3O-C6H4- elemental analysis: calc'd
			-			C=74.42, H=6.25, N=3.47; found
						C=74.57, H=6.29, N=3.51
5AA	4-F-C6H4-O-(CH2)2-	I	4-CH ₃ O-C ₆ H ₄ -	trans	4-MeO-C ₆ H ₄ -	elemental analysis: calc'd
						C=71.25, H=5.74, N=3.32; found
						C=71.34, H=5.73, N=3.43

	7			_	_	
elemental analysis: calc'd C=78.04, H=7.03, N=3.37; found			Data	mn=113-1150C	mp=122-123°C	
4-MeO-C ₆ H ₄ -			R ₂₀	4-MeO-C ₆ H ₄ -	C ₆ H ₅ -	
trans	E S S S S S S S S S S S S S S S S S S S	Rel. Stereo-	chemistry	3S,4R	trans	
4-CH ₃ O-C ₆ H ₄ -	H ₂₁ -E-F-		R ₂₃ -G-	C ₆ H ₅ -	4-CH ₃ O-C ₆ H ₄ -	
I			R22-F-	Ξ	I	
5AB C ₆ H ₅ -(CH ₂) ₄ -			R21-E-	(СН3)2СН-	C6H5-(CH2)2-	N(CH ₃)-
5AB			Ä.	5A	5N	

Dissolve 200mg (0.47mmol) of the β -lactam of Example 3G in 4mL EtOAc and add ~10mg 10% Pd/C. Hydrogenate at 1atm for 4h. Filter the mixture through Celite and concentrate. Chromatograph the residue over 40g SiO₂, eluting with 20% EtOAc-hexane to obtain 188mg (94%) of the title β -lactam as a colorless oil, CI MS: (M+1) 428.1.

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To a refluxing solution of 4.33 grams (.0205 moles) N-(4-methoxybenzylidine)-aniline and 7.6 grams (0.0410 moles) tributylamine in 40 mL heptane add,in portions, a solution of 4.03 grams (0.0205 moles) 5-phenylvaleroyl chloride in 15 mL heptane over about 2 hours, then reflux the solution for an additional 4 hours. Evaporate the solvent and take up the residue in 150 mL EtOAc. Wash with 1N HCl (2 x 30 mL), saturated NaHCO₃ (1 x 30 mL) and brine (1 x 30 mL), then dry over MgSO₄ and evaporate to give 7.69 grams of a semisolid. Recrystallization from 15% EtOAc in hexane to obtain 3.08 grams of the title compound, mp 75-76°C. An additional 2.31 g is obtained from the mother liquors by chromatography (silica gel, 5% ethyl acetate in hexane) and recrystallization.

Using a procedure similar to that of Example 7, the following compounds shown in Tables 7 and 7Acan be prepared:

Ex. D R A Stereo- CeHs-(CH2)3- CeHs-(CH	•											
D R A Stereo- CeHs-(CH2)3- H 4-CH3O-CeH4- trans		Data		elemental analysis: calc'd	C=72.10, H=5.81, N=6.73;	N=6.54	mp=91-93°C	mp=79-81ºC	elemental analysis: calc'd	C=73.69, H=5.89, N=3.44;	found C=73.36, H=5.77,	N=3.48
D R A A-CH ₃ O-C ₆ H ₄ -C ₆ H ₅ -(CH ₂) ₃ - H 4-CH ₃ O-C ₆ H ₄ -C ₆ H ₅ -(CH ₂) ₃ - H 4-CH ₃ O-C ₆ H ₄ -C ₆ H ₅ -(CH ₂) ₃ - H 4-CH ₃ O-C ₆ H ₄ -C ₆ H ₅ -(CH ₂) ₃ - H 4-CH ₃ O-C ₆ H ₄ -C ₆ H ₅ -(CH ₂) ₃ - H 4-CH ₃ O-C ₆ H ₄ -C ₆ H ₅		R4	4-(CH ₃ CH ₂ OC(O))- C ₆ H ₄ -	3-NO ₂ -C ₆ H ₄ -			4-((CH3CH2)2-N)-	4-NC-C ₆ H ₄ -			u.	
D R A A CH ₃ O-C ₆ H 4-CH ₃ O-C ₆ H C ₆ H ₅ -(CH ₂) ₃ - H 4-CH ₃ O-C ₆ H C ₆ H ₅ -(CH ₂) ₃ - H 4-CH ₃ O-C ₆ H C ₆ H ₅ -(CH ₂) ₃ - H 4-CH ₃ O-C ₆ H C ₆ H ₅ -(CH ₂) ₃ - H 4-CH ₃ O-C ₆ H C ₆ H ₅ -(CH ₂) ₃ - H 4-CH ₃ O-C ₆ H C ₆ H ₅ -(CH ₂) ₃ - H 4-CH ₃ O-C ₆ H C ₆ H ₅ -(CH ₂) ₃ - H 4-CH ₃ O-C ₆ H C ₆ H ₅ -(CH ₂) ₃ - H 4-CH ₃ O-C ₆ H C ₆ H ₅ -(CH ₂) ₃ - H 4-CH ₃ O-C ₆ H C ₆ H ₅ -(CH ₂) ₃ - C ₆ H C ₆ H ₆ -(CH ₂)- C ₆ H C ₆ H ₆ -(CH ₂)- C ₆ H C ₆ H ₆ -(CH ₂)- C ₆ H C ₆ H ₆ -(CH ₂)- C ₆ H C ₆ H ₆ -(CH ₂)- C ₆ H C ₆ H ₆ -(CH ₂)- C ₆ H C ₆ H ₆ -(CH ₂)- C ₆ H C ₆ H ₆ -(CH ₂)- C ₆ H C ₆ H ₆ -(CH ₂)- C ₆ H C ₆ H ₆ -(CH ₂)- C ₆ H C ₆ H ₆ -(CH ₂)- C ₆ H C ₆ H ₆ -(CH ₂)- C ₆ H C ₆ H ₆ -(CH ₂)- C ₆ H C ₆ H ₆ -(CH ₂)- C ₆ H C ₆ H ₆ -(CH ₂)- C ₆ H C ₆ H ₆ -(CH ₂)- C ₆ H C ₆ H ₆ -(CH ₂)- C ₆ H C ₆ H ₆ -(CH ₂)-		Relative Stereo-	trans	trans			trans	trans	trans			
CeH5-(CH2)3- CeH5-(CH2)3- CeH5-(CH2)3- CeH5-(CH2)3- CeH5-(CH2)3-	4 Z	ď	4-CH ₃ O-C ₆ H ₄ -	4-CH ₃ O-C ₆ H ₄ -			4-CH ₃ O-C ₆ H ₄ -	4-CH ₃ O-C ₆ H ₄ -	4-CH ₃ O-C ₆ H ₄ -			·
		 Œ	I	I			I	H	I			
Ex. 78 78 76 76 76 76 76 76 76 76 76 76 76 76 76		Q	C ₆ H ₅ -(CH ₂) ₃ -	C ₆ H ₅ -(CH ₂) ₃ -			C ₆ H ₅ -(CH ₂) ₃ -	C ₆ H ₅ -(CH ₂) ₃ -	C ₆ H ₅ -(CH ₂) ₃ -			
		EX.	7A	78			7C	7.0	7E			

					_						
mp=103-104°C	elemental analysis: calo'd	C=78.42, H=6.58, N=3.39;	found C=78.08, H=6.51,	N=3.40	mp=90-92°C	mp=129-130°C	4-CH ₃ O-C ₆ H ₄ - mp=96.5-97.5°C	mp=89-91°C	4-CH ₃ O-C ₆ H ₄ - mp=92.5-93.5°C	4-CH ₃ O-C ₆ H ₄ - EIMS (M)=415	mp=84-85°C
-CHOCH3	4-(CH ₃ C(O))-	C ₆ H ₄ -			OCH ₃	CH ₃	4-CH ₃ O-C ₆ H ₄ -	C ₆ H ₅ -	4-CH ₃ O-C ₆ H ₄ -	4-CH ₃ O-C ₆ H ₄ -	C ₆ H ₅ -
trans	trans				trans	trans	trans	trans	trans	trans	trans
4-CH ₃ O-C ₆ H ₄ -	4-CH ₃ O-C ₆ H ₄ -				4-CH ₃ O-C ₆ H ₄ -	4-CH ₃ O-C ₆ H ₄ -	4-((CH ₃) ₂ CH-O)- C ₆ H ₄ -	FHOO (N=)	4-(CH ₃ (CH ₂) ₂ -O)- C ₆ H ₄ -	⁶ H20	4-(CH3OC(O))-C6H4-
H	I				H	I	н	Н	Η	н	I
C ₆ H ₅ -(CH ₂) ₃ -	C ₆ H ₅ -(CH ₂) ₃ -				C ₆ H ₅ -(CH ₂) ₃ -	C ₆ H ₅ -(CH ₂) ₃ -	C ₆ H ₅ -(CH ₂) ₃ -	C ₆ H ₅ -(CH ₂) ₃ -	C ₆ H ₅ -(CH ₂) ₃ -	C ₆ H ₅ -(CH ₂) ₃ -	C ₆ H ₅ -(CH ₂) ₃ -
7F	76			i	Ę	71	M 2	02	7P	22	7.1

			T								T	υ Ο	Γ	T		7
4-CH ₃ O-C ₆ H ₄ - EIMS (M)=420	-	CIMS (M+1)=402	4-CH ₂ O-C ₆ H ₄₋ mn-96 5-97 50C	4-CH ₃ O-C ₆ H ₄ - EIMS (M)=429		4-CH ₃ O-C ₆ H ₄ - EIMS (M)=429		EIMS (M)=431			20°5.0-95.50℃	mp=136.5-137.0°C	202 79-39 5±0m	_		
4-CH ₃ O-C ₆ H ₄ -		C ₆ H ₅ -	4-CH30-CeH4-	4-CH ₃ O-C ₆ H ₄ -		4-CH ₃ O-C ₆ H ₄ -		4-CH ₃ O-C ₆ H ₄ - EIMS (M)=431			76115-	4-CH3O-C ₆ H ₄ -	4-I-C ₆ H ₄ -	4-CH ₃ O-C ₆ H ₄ -		
trans		trans	trans	trans		cis		trans		trane		trans	trans	trans		
OCH ³	L 100 107 4	4-(CH30CH20)-C6H4-	4-((CH ₃) ₂ N)-C ₆ H ₄ -	-0-10-0-1		— C-C-C-C-C-C-C-C-C-C-C-C-C-C-C-C-C-C-C-		HOO CH ³	H³CO	4-(CH3CH2-O)-CEH4-	4-CHO-h	Cli30-C6114-	4-CH ₃ O-C ₆ H ₄ -	4-(CH ₃ (CH ₂) ₃ -0)-	C ₆ H ₄ -	
I		=	ᆂ	I		I		Ξ		I	I		Ŧ	I		
C ₆ H ₅ -(CH ₂) ₃ -	CeHe-(CHa)a-	612101610	C6H5-(CH2)3-	C ₆ H ₅ -(CH ₂) ₃ -		C6H5-(CH2)3-		C6H5-(CH2)3-		C ₆ H ₅ -(CH ₂) ₃ -	4-02N-C6H4-(CH2)2-		C6H5-(CH2)3-	C ₆ H ₅ -(CH ₂) ₃ -		C.H.J.(CH.J.)
S	1	ī	2	≥	Î	₹	?	<		≿	72	7 7 7	X	7AB		7AF

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4-CH ₃ O-C ₆ H ₄ - elemental analysis: calc'd	C=78.17, H=6.31, N=3.51;	found C=78.22, H=6.36,	N=3,59	4-CH ₃ O-C ₆ H ₄ - FAB mass spec	400(100)	4-CH ₃ O-C ₆ H ₄ - mp=105-106°C	elemental analysis; calc'd	C=78.29, H=7.27, N=3.26;	found C=78.37, H=7.26,	N=3.41	mp=54-56°C	mp=55-57°C	elemental analysis; calc'd	C=74.42, H=6.25, N=3.47;	found C=74.13, H=6.03,	N:306
4-CH ₃ O-C ₆ H ₄ -				4-CH ₃ O-C ₆ H ₄ -		4-CH ₃ O-C ₆ H ₄ -	4-CH ₃ O-C ₆ H ₄ -				C ₆ H ₅ -	C ₆ H ₅ -	C ₆ H ₅ -			
trans				trans		trans	trans				trans	trans	trans			
4-CH ₃ O-C ₆ H ₄ -				4-CH ₃ O-C ₆ H ₄ -		4-CH ₃ O-C ₆ H ₄ -	4-CH ₃ O-C ₆ H ₄ -				4-CH ₃ O-C ₆ H ₄ -	4-CH ₃ O-C ₆ H ₄ -	4-CH ₃ O-C ₆ H ₄ -			
I				I		I	H				I	I	Н			
		•				(CH ₂) ₃ -	C ₆ H ₅ -(CH ₂) ₅ -				4-0 ₂ N-C ₆ H ₄ -0- (CH ₂) ₂ -		4-(O-(CH2)2-		
7AI				7		7AK	7AM				7AN	7AO	7AP			

				 	——
¹ H NMR (CDCl ₃) 7.97-7.78 (m,2H); 7.69 (d, J=8Hz,1H); 7.45-7.69 (m,10H); 6.90 (d,	J=8Hz,ZH); 6.63 (d,J= 8Hz, 1H); 5.17(d,J=6Hz,1H); 4.15- 4.0 (m,1H); 3.82 (s,2H); 3.5 (dd,J=6,14Hz,1H); 2.96(dd, L=9 14Hz,1H)	mp=111-112°C	MS CI+ (M+1)=426	mp=122-124ºC	mp=105-106°C
C ₆ H ₅ -			P >		4-(C ₆ H ₅ -CH ₂ O)- C ₆ H ₄ -
cis Si		trans	trans	trans	trans
4-CH ₃ O-C ₆ H ₄ -		4-CH ₃ O-C ₆ H ₄ -	4-CH ₃ O-C ₆ H ₄ -	4-CH ₃ O-C ₆ H ₄ -	4-(C ₆ H ₅ -CH ₂ O)-C ₆ H ₄ -
н		н	Ξ	I	I
S		C ₆ H ₅ -(CH ₂) ₃ -	C ₆ H ₅ -(CH ₂) ₃ -	C ₆ H ₅ -(CH ₂)3-	C ₆ H ₅ -(CH ₂) ₃ -
7AQ		7AR	7AS	7AT	7AU

	Data	mp=186-187°C	mp=120-123°C	mp=243-245.5°C	mp=97-98.5°C	mp=78-81°C	mp=60-63°C	mp=108-110°C
	R20	C ₆ H ₅ -	C ₆ H ₅ -	C ₆ H ₅ -	4-CH ₃ O-C ₆ H ₄ -	4-CH ₃ O-C ₆ H ₄ -	4-CH ₃ O-C ₆ H ₄ -	4-CH ₃ O-C ₆ H ₄ -
z, s z, g,	Rel. Stereo- chemistry	cis	cis	cls	cis	•••	trans	cis
R ₂₁ - E F - C	R ₂₃ -G-	4-CH ₃ O-C ₆ H ₄ -	4-CH ₃ O-C ₆ H ₄ -	4-CH ₃ O-C ₆ H ₄ -	-C(O)ОСН ₂ СН ₃	4-CH ₃ O-C ₆ H ₄ -	4-CH ₃ O-C ₆ H ₄ -	4-CH ₃ O-C ₆ H ₄ -
	H22-F-	I	I	I	エ	C ₆ H ₅ -	C ₆ H ₅ -	C ₆ H ₅ -CH ₂ -
	R ₂₁ -E-	CH ₃ O-C(O)- CH=C(CH ₃)- NH-	C ₆ H ₅ -(CH ₂) ₂ - N(CH ₃)·	N-N-	C ₆ H ₅ -(CH ₂) ₃ -	C ₆ H ₅ -	cyclo-C ₅ H ₉ -	C ₆ H ₅ -
	ËX.	7.7	7K	7	K	7AC	7AD	7AF

	elemental analysis: calc'd	C=76.56, H=8.80, N=3.31;	found C=76.37, H=8.90,	N=3.46	00C11 111 1100	00/11-411-011	elemental analysis: calc'd	C=76.22, H=5.45, N=3.29;	found C=76.00, H=5.46,	
	4-CH ₃ O-C ₆ H ₄ -				4-CH ₂ O-C _c H ₄ - mn ₋₁₁₄ 147 ₂₀ C	30 00 14	4-CH ₃ O-C ₆ H ₄ -			
	trans				cis		cis	-		
	4-CH3O-C6H4-				4-CH ₃ O-C ₆ H ₄ -		4-CH3O-C ₆ H ₄ -			
-	Ε				C ₆ H ₅ -	•	E			
יים, כ		-			C ₆ H ₅ -CH ₂ -	6)		
746	?				AH	177	ָרָ ר			

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EXAMPLE 8

Stir a mixture of 981mg (3.01mmol) of the cis β -lactam of Example 1AK, above, and 20mg 10% palladium on carbon in 10 mL ethyl acetate under 1atm hydrogen gas at room temperature for 24h. Filter the mixture through Celite and concentrate in vacuo. Chromatograph the residue over 50g SiO₂, eluting with 40% ethyl acetate-hexane to obtain 818mg (92%) of the title compound as a yellowish solid, mp = 142.0 - 142.5°C.

Using a similar procedure, the following compounds shown in Tables 8 and 8A can be prepared, and using conventional procedures, the amino group of compound 8A and the amino group of compound 8B can be protected with a t-butoxycarbonyl (BOC) group to obtain compounds 8G and 8H, respectively:

		Data		4-CH ₂ O-C ₆ H ₄ - mn=138 5.139 50C	4-CH ₂ O-C _c H ₄ - FAR MS (M ₁₁)-207 4	mn=46-480C	4-CH ₃ O-C ₆ H ₄ - m _D =129 0.131 00 C		4-CH ₃ O-C ₆ H ₄ - mp=171 0-171 50C	4-CH ₃ O-C ₆ H ₄ - CI MS:(M+1)=487	
		R4		4-CH ₃ O-C ₆ H ₄ -	4-CH ₃ O-C ₆ H ₄ -	3-NH2-CeH4-	4-CH3O-CeH4-		4-CH ₃ O-C ₆ H ₄ -	4-CH ₃ O-C ₆ H ₄ -	
	Relative	Stereo-	chemistry	cis	trans	trans	trans		trans	cis	
A N N N N N N N N N N N N N N N N N N N		∢		4-NH ₂ -C ₆ H ₄ -	4-NH ₂ -C ₆ H ₄ -	4-CH ₃ O-C ₆ H ₄ -	4-CH ₃ O-C ₆ H ₄ -		4-OH-C ₆ H ₄ -	4((CH ₃) ₃ C-O-C(O)-	NH)-C ₆ H ₄ -
		Œ		I	I	I	н		Н	н	
		۵		C ₆ H ₅ -(CH ₂) ₃ -	C ₆ H ₅ -(CH ₂) ₃ -	C ₆ H ₅ -(CH ₂) ₃ -	4-NH ₂ -C ₆ H ₄ -	(CH ₂) ₃ -	C ₆ H ₅ -(CH ₂) ₃ -	C ₆ H ₅ -(CH ₂) ₃ -	
		Ж.		88	8C	8D	9E		8	8H	

			Data	mp_126_1070C	J-/61-90-13/10	CI MS:(M+1)=397
			Ran	4-CH ₂ O ₂ C ₂ H ₂ -	4-CH-O C-H	-4013O-0614-
Z, Z	3	Rel. Stereo-	chemistry	3S.4R	3S 4B	F O
Pa-E			H ₂₃ -G-	4-NH2-C ₆ H ₄ -	4((CHa)aC-O-C(O)-	NH)-C6H4-
			R ₂₂ -F-	I	I	
			R21-E-	CH ₃ CH ₂ -	CH3CH2-	
			Ä.	8A	86	

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EXAMPLE 9

STEP 1: Combine 5-phenylvaleric acid (89.9 g, 0.504 mol) and thionyl chloride (89.3 mL, 1.225 mol), heat to 70°C and reflux for 1h. Vacuum distill (50 - 100 mm Hg) the excess thionyl chloride and add 200 mL of dry toluene to the resultant residue. Vacuum distill again, then add 188 mL of dry THF to the crude 5-phenylvaleroyl chloride and use the resulting solution directly in the next step.

STEP 2: Combine 76 g (0.4289 mol) of R-(+)-4-benzyl-

oxazolidinone and 1.3 L of dry THF under dry nitrogen atmosphere. Cool the resulting solution to -78°C and add 278 mL of a 1.6 M solution of n-butyllithium in hexane over 30-40 minutes. Stir for an additional 30 minutes, then add the solution of Step 1 over a period of 45 min. Allow the mixture to warm to 0°C and stir for 1 h. Quench the reaction mixture by adding 673.6 mL of K₂CO₃ (1 M aqueous solution) and stir for 1 h. Distill off the THF under vacuum at 30-35°C. Dilute the residue with 1 L of water and extract with 3x800 mL of CH₂Cl₂. Combine the organic extracts and wash with 800 mL of water, then with 800 mL of brine. Dry the organic extracts over MgSO₄, filter, then concentrate *in vacuo* to an oil. Dissolve the oil in 200 mL of hexane, then distill off the hexane under vacuum. Repeat the hexane treatment two more times, then

directly in the next step.

STEP 3: Cool the solution of Step 2 to -5°C to 0°C under dry nitrogen atmosphere. Add 129.8 mL of di-n-butylboron triflate, maintaining the temperature of the reaction mixture at -6°C to -3°C. Following the addition, stir the mixture for 10 min., then add 97.12 mL of diisopropylethylamine, again maintaining the temperature at -6°C to

dissolve the oil in 1.7 mL of CH₂Cl₂. The resulting solution is used

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-3°C. Following the addition, stir the mixture at 0°C for 30 min., then cool the mixture to -78°C and stir for 30 min.. Add 57.4 mL of p-anisaldehyde and stir the mixture at -78°C for 30 min., then at 0°C for 1 h. While maintaining the temperature at 0°C to 5°C, quench the mixture by adding 688.2 mL of a pH 7 buffer solution (68 g KH₂PO₄, 12 g NaOH and 800 mL of water), then add 473 mL of 30% H₂O₂ and stir the resulting mixture at 0°C for 1 h. Extract the mixture with 3x600 mL hexane:ethyl actetate (1:1), combine the organic extracts and wash with 800 mL of saturated NaHCO₃ (aqueous), then with 800 mL of brine. Dry the organic extracts over NaSO₄, filter, and evaporate to an oil. Crystallize the oil from hexane/ethyl acetate (1:1) to give 176 g of the product as a white solid.

STEP 4: Combine the product of Step 3 (170 g, 0.36 Mol), 1595 mL of THF and 400 mL of water, stir the mixture and cool to about 3°C. Add 226 mL (2.156 Mol) of 30% H₂O₂ to the mixture over 15 min., then add a solution of LiOH (36.2 g, 0.862 Mol) in 400 mL of water over a period of 30 min. Stir the reaction mixture at 0°C to 5°C for 3 h. Add a solution of 272 g of sodium sulfite in 850 mL of water over 70 min., keeping the temperature under 27°C. Concentrate the solvent under vacuum and add 7 L of water. Extract with 4x1.7 L of toluene. Acidify the aqueous layers to pH 2.4 with 3 N HCl. Extract with one 2.6 L portion and two 1.7 L portions of ethyl acetate. Combine the ethyl acetate extracts, wash with brine, dry over NaSO₄, filter, then evaporate to give the product as a white solid, 112 g.

STEP 5: Combine the product of Step 4 (19.47 g, 62 mmol), 400 mL of acetonitrile, 9.49 g (62 mmol) of 1-hydroxybenzotriazole (HOBT), 22.91 g (186 mmol) of p-anisidine and 14.05 g (68.2 mmol) of dicyclohexylcarbodiimide (DCC). Stir the reaction mixture at 40°C for 4 h and confirm the consumption of starting material by TLC (6:4 hexane/ ethyl acetate). Concentrate the mixture to 1/3 its volume and partition between 300 mL of water and 300 mL of ethyl acetate. Filter the organic layer, then wash with 200 mL of 1 N HCl, then with two 100 mL portions of saturated NaHCO₃, and two 100 mL portions of brine. Dry the

organic layer over NaSO₄ and concentrate to give the product as a brown solid, 24 g.

STEP 6: Combine the product of Step 5 (115 g, 0.2745 Mol) and 2.3 L of THF under dry nitrogen atmosphere and cool to -70°C. Stir the

5 mixture while adding a solution of 137 mL (0.551 Mol) of tri-n-butylphosphine in 113 mL THF, and 163 mL (1.03 Mol) of diethylazodicarboxylate (DEAD) over 2 h. Allow the mixture to warm to room temperature and stir overnight. Remove the solvent under vacuum. Filter the residue through a plug of silica gel using CH₂Cl₂/

10 hexane/ ethyl acetate (70:24:6) as the eluant. Evaporate the solvent and purify the residue by preparative HPLC (silica gel, 15% ethyl acetate/ hexane) to give 88 g of the (3R,4S) enantiomerically pure title compound, [\alpha]_D²⁵ = -19.3° (MeOH).

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Example 10

The compound of Example 7AU (0.686 g, 0.0012 moles) dissolved in 1:1 ethanol:ethyl acetate is hydrogenated over 0.70 grams 10% Pd on carbon at 50 psi for 16 hours. The resulting product is chromatographed (silica gel, 80:20 hexane:ethyl acetate) to give 0.432 grams of the title compound, mp 160-161°C.

Using substantially the same procedure the following compound can be prepared:

Example 10A

Elemental Analysis
Calculated for C₂₅H₂₅NO₃
C, 77.49; H, 6.50; N, 3.61
Found: C, 77.47; H, 6.46; N, 3.74

Example 11

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A flask is charged with the compound of Example 7J (27 g, 73.6 mmole), acetone (0.6 l), water (1.3 ml, 73 mmole), and p-toluenesulfonic acid-monohydrate (15.4 g, 81.1 mmole). The solution is stirred at 22°C for 5.5 h and the product collected by filtration (34.1 g). Recrystallization from methanol affords the title compound,26.0 g (79% yield), mp 200-202°C.

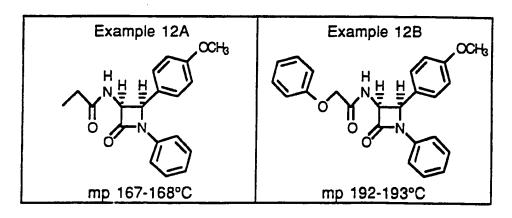
Example 12

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To a solution of the product of Example 11 (0.60 g, 1.36 mmole), triethylamine (0.14 g, 1.4 mmole) in CH₂Cl₂ (2 ml) was added phenylacetylchloride (0.310 g, 2.0 mmole) dropwise over 0.5 h. After 5 h the reaction mixture was concentrated to dryness, and the residue purified by chromatography (silica, 2:1 hexane: ethyl acetate) to afford 0.27 g (51% yield) of the title compound, mp 217-218°C.

Using substantially the same procedure, the following compounds can be prepared:



Example 13

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To a biphasic mixture of the product of Example 11 (0.80 g, 1.8 mmole), CH₂Cl₂ (15 ml) and 30% aqueous tetrabutylammonium hydroxide (2.36 ml, 3.64 mmole) was added p-toluenesulfonylchloride (0.515 g, 2.7 mmole). After 2 h the reaction mixture was washed with 1X 1 N HCl, 2X H₂O and the organic layer dried over MgSO₄. Concentration followed by recrystillaztion from ethyl acetate afforded 0.38 g (50% yield) of the title compound, mp 204-205°C.

Example 14

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To a solution of the product of Example 11 (0.8 g, 1.8 mmole), methanol (20 ml) and triethylamine (0.19 g, 1.8 mmole) was added phenylacetaldehyde (0.44 g, 3.6 mmole). After 0.25 h, NaBH₃CN (0.172 g, 2.7 mmole) and ZnCl₂ (0.174 g, 1.3 mmole) were added to the reaction. After 3.5 h, the reaction was quenched with ammonium chloride, concentrated partially in vacuo, and dissolved in CH₂Cl₂. The organic layer was washed 2X with water, dried and concentrated to afford crude product. Recrystallization from CH₂Cl₂ afforded 0.44 g (65% yield) of the title compound, mp 138-139.5°C.

Using substantially the same procedure, the following compounds can be prepared:

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Example 15

Add 49 mL (49 mmol) of 1M tetrabutylammonium fluoride 49 mL, 49 mmol, 1M in THF)to a room temperature solution of the compound of Example 1AS (5.1g, 9.8 mmol) in THF (25 mL). Allow the mixture to stir overnight. TLC (50% EtOAc/hexanes) indicates consumption of starting material. Transfer the reaction mixture to a separatory funnel, partion between saturated ammonium chloride and ether, extract with ether. Combine the etheral extracts, wash with water and brine, dry over anhydrous Na₂SO₄, filter and concentrate to a residue. Chromatograph (SIO₂, 30-40% EtOAc/hexane) affords 3.31g (84%) of the title compound, mp 91-92°C.

The following compounds can be prepared via substantialy the same procedure:

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Example 16

Add MnO₂ (0.64g, 7.4 mmol) to a solution of the product of Example 15A (0.20g, 0.5 mmol) in CH₂Cl₂ (50 mL) at room temperature. Allow the mixture to stir overnight. TLC (20% EtOAc/hexanes) indicates consumption of starting material. Filter the mixture through celite washing the filtercake well with CH₂Cl₂. Concentrate the filtrate to obtain 0.19g (95%) of the title compound, mp 129-130 °C.

Using substantially the same procedure, the following compound can be prepared:

Example 16A

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Example 17

Add m-chloroperbenzoic acid (.16g, .092 mmol) to a solution of the compound of Example 1AU (0.31 g, 0.74 mmol) in CH₂Cl₂ (4 mL) at room temperature. Monitor the reaction by TLC (50% EtOAc/hexanes). Upon consumption of starting material (~1h), add Ca(OH)₂ (0.1g, 1.3 mmol) Stir the mixture for an additional 15 min..

Filter the mixture through celite washing the filtercake well with CH₂Cl₂. Concentrate the filtrate onto silica gel, using enough silica gel until a free flowing powder is obtained. Load the resulting powder onto a chromatography column loaded with silica gel and 5% MeOH/CH₂Cl₂. Elute with 5% MeOH/CH₂Cl₂ to obtain 0.26 g of the title sulfoxide

(Example 17), mp 134-135°C and 0.50 g of the analogous sulfone: Example 17A

The following compounds can be prepared via substantially the same procedure:

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Example 18

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Reflux a mixture of the compound of Example 1AW (1.72 g, 3.49 mmol), 20 mL of THF and 3N HCl (20 mL) overnight. Monitor the reaction by TLC (50% EtOAc/hexanes). Upon consumption of starting material cool the mixture to room temperature, neutralize with saturated NaHCO3 and extract with ethyl acetate. Combine the extracts, wash with water and brine, dry over anhydrous Na₂SO₄, filter and concentrate to a solid. Recrystallize from CH₂Cl₂/MeOH to obtain 0.322g of the title compound, mp 190.5-191.5 °C.

Using substantially the same procedure the following compound can be prepared:

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Example 18A

Example 19

Add a solution of NaBH₃CN (0.19g, 3.0 mmol) and ZnCl₂

(0.21g, 1.5 mmol) in methanol to a room temperature solution of the product of Example 16A (1.0g, 2.5 mmol) and morpholine (0.44 mL, 5.0 mmol) in THF. Monitor the reaction by TLC (50% EtOAc/hexanes).

Upon consumption of starting material the mixture was diluted with 0.1 N NaOH (120 mL) and remove the organic solvents on a rotary evaporator.

Extract the resulting solution with ethyl acetate. Combine the extracts, wash with water and brine, dry over anhydrous Na₂SO₄, filter and concentrate to a solid. Recrystallize from Et₂O/hexanes to obtain 0.81g (69%) of the title compound, mp 100-101 °C.

The following compounds can be prepared by substantially the same method:

Heat a solution of the compound of Example 1AR (1.10g, 2.95 mmol), 15% H_2O_2 (0.45 mL) in acetic acid (3 mL) to a 100 °C for 3.5h with TLC monitoring (5% MeOH/CH₂Cl₂). Upon consumption of the starting compound, cool to room temperature, neutralize with sat. Na_2CO_3 and dilute with ethyl acetate. Filter the mixture and wash the filtrate with water and brine, dry over anhydrous Na_2SO_4 , filter and concentrate to a residue. Chromatograph the residue (silica gel, 10% MeOH/CH₂Cl₂) to give the title compound, FAB MS (M+1) = 389.

Example 21

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Add freshly prepared AgO (0.40 g, 1.73 mmol) to a solution of the product of Example 15A (0.46g, 1.15 mmol) and methyl iodide (0.21 mL, 3.45 mmol)in dry DMF (5 mL). Heat the mixture to 40-45 °C.with TLC monitoring (50% EtOAc/hexanes). Add proportional amounts of AgO and methyl iodide until TLC indicates consumption of starting compound. Cool to room temperature, particn between water and ethyl acetate, extract with ethyl acetate. Combine ethyl acetate

extracts, wash with water and brine, dry over anhydrous Na_2SO_4 , filter and concentrate to a residue. Chromatograph the residue (silica gel, 30% EtOAc/hexanes) to give the title compound, FAB MS (M+1) = 416.

The following compound can be prepared by substantially

5 the same procedure:

Example 21A

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Example 22

Add freshly prepared Jone's reagen. (8 mL) dropwise to a solution of the product of Example 16 (2.76, 6.94 mmol) in acetone (80 mL) maintaining the temperature of the reaction mixture between 15-20 °C. Monitor by TLC (5% MeOH/CH₂Cl₂). Upon consumption of starting compound, quench the reaction with methanol. Concentrate to a residue and partion the residue between CH₂Cl₂ and water. Extract with CH₂Cl₂, combine the extracts, wash with water, 10% Na₂SO₃ (aq) and brine, then dry over anhydrous Na₂SO₄. Filter and concentrate to afford 2.90g of the title compound, mp 64-65 °C.

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The following compound can be prepared by substantially the same procedure.

Example 22A

mp 158-159°C

Example 23

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Add EDCI (0.2g, 1.03 mmoL) to a room temperature solution of the product of Example 22A (0.30, 0.72 mmol), N-methylmorpholine (0.11 mL, 0.94 mmol), morpholine (0.13 mL, 0.42mmol) and HOBT (0.12g, 0.87 mmol) in CH₂Cl₂ (8 mL). Stir the mixture overnight. Monitor by TLC (5% MeOH/CH₂Cl₂). Upon consumption of the starting compound, dilute with CH₂Cl₂, wash with 1M HCl, water, dry over anhydrous Na₂SO₄, filter and concentrate to a residue. Chromatogaph the residue (SiO₂, 3% MeOH/CH₂Cl₂) to afford 0.3g (86% yield) of the title compound, mp 61-62 °C.

Add EDCI (0.2g, 1.03 mmoL) to a room temperature solution of the product of Example 22A (0.30, 0.72 mmol), N-methylmorpholine (0.11 mL, 0.94 mmol), ethanol (0.1 mL, 1.44 mmol) and HOBT (0.12g, 0.87 mmol) in CH₂Cl₂ (8 mL). Stir the mixture overnight. Monitor by TLC (5% MeOH/CH₂Cl₂). Upon consumption of starting compound, dilute with CH₂Cl₂, wash with 1M HCl, water, dry over anhydrous Na₂SO₄, filter and concentrate to a residue. Chromatogaph the residue (SiO₂, 3% MeOH/CH₂Cl₂) to afford 0.33g (100% yield) of the title compound, mp 76-77 °C.

The following compound can be prepared by substantially

15 the same procedure:

Example 24A

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Example 25

Add methanesulfonyl chloride (0.05 mL, 0.67 mmoL) to a 0°C solution of the product of Example 8B (0.26, 0.67 mmol), pyridine(3 drops) in CH₂Cl₂ (5 mL). Stir the mixture overnight. Monitor by TLC (50% EtOAc/hexanes). Upon consumption of starting material, dilute with CH₂Cl₂, wash with 0.5M HCl, 5% NaHCO₃, water and brine, dry over anhydrous sodium sulfate, filter and concentrate to a residue. Chromatogaph the residue (SiO₂, 50% EtOAc/hexanes) to afford 0.18g 10 (58% yield) of the title compound, FAB MS (M+1) = 465.

By substantially the same procedure, the following

compounds can be prepared:

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Add acetyl chloride (0.04 mL, 0.57 mmoL) to a solution of the product of Example 8C (0.20, 0.52 mmol) and triethylamine(0.11 mL, 0.79) in CH₂Cl₂ (3 mL) at room temperature. Monitor by TLC (50% EtOAc/hexanes). Upon consumption of starting material (~3h), dilute with CH₂Cl₂, wash with 5% NaHCO₃, water and brine, dry over anhydrous Na₂SO₄, filter and concentrate to afford 0.19g, (85% yield) of the title compound, mp 153-154 °C.

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Example 27

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Reflux a suspension of the product of Example 16 (0.6g, 1.5 mmol), hydroxylamine hydrochloride (0.4g, 4.5 mmol), sodium acetate (0.4g 4.5 mmol), methanol (12mL) and water (5mL) overnight. Monitor by TLC (50% EtOAc/hexanes). Upon consumption of starting material, evaporate to dryness, partition the residue between water and ethyl acetate, extract with EtOAc, combine the extracts, wash with water and brine, dry over anhydrous Na₂SO₄, filter and concentrate to a residue. Chromatograph the residue (silica gel, 20% EtOAc/hexanes) to provide the title compound, mp 98-99 °C; and Example 27A:

5 Reflux a solution of the product of Example 17 (3.2g, 7.38 mmol), CH₂Cl₂ (15 mL) trifluoracetic anhydride (15 mL) for 15 min. Monitor the reaction by TLC (100% EtOAc). Upon consumption of starting material, distill to remove most of solvent, cool to room temperature, and evaporate to a residue. Dissolve the residue in 50% triethylamine/methanol solution (30 mL) stir for 15 min., evaporate to 10 dryness on a rotovap. Redissolve in CH₂Cl₂, wash with NH₄Cl (sat.), dry over anhydrous Na₂SO₄, filter and concentrate onto enough silica gel (1g SiO₂/ mmol substrate) that a free flowing powder results. Load the powder onto a chromatography column packed with silica gel and 30 % EtOAc/hexanes. Elute with 30-60% EtOAc/hexanes to provide 15 2.65g (89%) of a residue. Recrystallize from Et₂O/CH₂Cl₂ to give the title compound, mp 134-135°C.

Example 29

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Dissolve the product of Example 28 (1.81g, 4.49 mmol) in THF (25 mL) cool to 0 °C. Add 1N NaOH (5.39 mL, 5.39 mmol), and a

solution of aqueous ammonia (16.8 mL, 5.39 mmol), followed by cholorox (6.7 mL, 5.39 mmol). Monitor the reaction by TLC (50% EtOAc/hexane). Upon consumption of starting material, dilute with EtOAc, wash with water and brine, dry over anhydrous Na₂SO₄ and concentrate to provide the sulfinamine (1.88g).

Dissolve the sulfinamine (1.88g, 4.49 mmol) in CH₂Cl₂ (50 mL), add m-chloroperbenzoic acid (1.70g, 9.88 mmol). Monitor the reaction by TLC (50% EtOAc/hexane). Upon consumption of starting material, quench with solid Ca(OH)₂ (1.78g, 24.0 mmol), stir for 20 min., filter and concentrate onto enough silica gel (1g SiO₂/ mmol substrate) that a free flowing powder results. Load the powder onto a chromatography column packed with silica gel and 50 % EtOAc/hexanes. Elute with 50% EtOAc/hexanes to provide 0.49g (24%) of the title compound, mp 174-176°C.

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Example 30

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Add BBr₃ (5.15 mL, 5.15 mmol, 1M in CH₂Cl₂) to a 0 °C solution of the compound of Example 7O (0.768g, 2.06 mmol) in CH₂Cl₂ (25 mL). Monitor the reaction by TLC (30% EtOAc). Upon consumption of starting material, quench with NaHCO₃ (sat.) and methanol, stir for 30 min., wash with NaHCO₃ (sat.) and water, dry over anhydrous Na₂SO₄, filter and concentrate onto enough silica gel (1g SiO2/ mmol substrate) such that a free flowing powder results. Load the powder onto a chromatography column packed with silica gel and 100% EtOAc. Elute with 100% EtOAc followed by 5% MeOH/EtOAc to provide 0.234g (32%) of the title compound, CI MS (M+1) = 359.

Reflux a mixture of the product of Example 16 (0.23g, 0.6 mmol) ethylene glycol (0.2mL, 3.6 mmol), p-toluene sulfonic acid and toluene (5 mL) overnight. Monitor by 1H NMR and TLC (50% EtOAc/hexanes). Cool to room temperature, wash with NaHCO₃(sat.), water and brine, dried over anhydrous Na₂SO₄, and concentrate to give 0.27g (100%) of the title compound, EI MS (M) = 443.

The following compound can be prepared by substantially the same procedure:

Example 31A

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Stir a solution of 388mg (1.00 mmol) of the compound of Example 8F, and 180mg (1.20 mmol) chloramine-T Nal in 4.6 mL DMF. Add 377mg (1.2mmol) and stir for 18h at room temperature. Partition the reaction between 30 mL 1N HCl and 30 mL ethyl acetate. Wash the organic layer with 10% aqueous Na₂SO₃ and dry the organic solution with MgSO₄. Concentrate in vacuo and chromatograph the residue over (silica gel, 40% ethyl acetate-hexane) to give 170mg of the title compound, Cl MS (M+1) = 514, and 41mg of the diodo analog (Example 32A):

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Stir 400 mg (0.96 mmol) of the compound of Example 8E, in 25 mL acetic acid and 5mL water at 0°C and add 133 mg (1.92 mmol) NaNO₂ in 4.7 mL water. Stir for 20 min. at 0°C add 212 mg (3.26 mmol) NaN₃ in 9 mL water and stir for 3h while warming to room temperature. Dilute with ethyl acetate and neutralize with NH₄OH. Dry the ethyl acetate layer with MgSO₄ and concentrate to a residue. Recrystallize the residue from ether-hexanes to give the titled compound, mp = 80 - 84°C.

Example 34

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Dissolve 300 mg (0.77 mmol) of the compound of Example 8F, in 3 mL CH₂Cl₂ and add 98 μL (120 mg, 0.80 mmol) 3carbomethoxypropionyl chloride and 146 μL (109 mg, 0.84 mmol)
Hünig's base. Stir at room temperature for 1.5h. Add another full portion of acid chloride and Hünig's base and stir for an additional hour.
Partition the reaction between ethyl acetate and 1N HCl. Dry the ethyl acetate layer with MgSO₄ and concentrate to a residue. Chromatograh

the residue (SiO_2 , 40% ethyl acetate-hexane) and filter through grade I basic alumina eluting with 50%ethyl acetate-hexane to give 334 mg (86%) of the title compound, EI MS (M+) = 501.25.

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Example 35

$$\mathsf{Ph}(\mathsf{CH}_2)_3 \\ \mathsf{O} \\ \mathsf{O} \\ \mathsf{OCH}_2 \\ \mathsf{Bn}$$

Benzyl bromide (0.44 g) was added to a solution of the compound of Example 15B (1.0 g) in acetone (15 mL) containing K₂CO₃ (0.715 g). The reaction was heated at reflux for 26 h. The reaction mixture was then poured into water and the product extracted with ethyl acetate. The crude product was recrystallized from ethyl acetate/hexane to give (0.908 g, 74% yield) of the desired product, mp 115-116°C.

The following compounds were prepared via substantially the same procedure:

$$CIMS(M+1) = 474$$

Elemental analysis: calculated for C₂₇H₂₉NO₃: C, 78.04; H, 7.03; N 3.37 Found: C, 78.00; H, 7.02; N, 3.55 5

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Example 36

The compound of Example 7AI (0.19 g) was cooled to -20°C. To this ws added a solution of diethyl zinc in toluene(4.3 mL of a 1.1 M solution) followed by diiodomethane (2.56 g). The reaction mixture was slowly allowed to warm to ambient temperature over three hours. Then the reaction mixture was warmed to 45°C for 5 min. After cooling the reaction mixture was treated with aqueous NH₄Cl and product extracted with diethyl ether. The organic layer was washed with water, brine and concentrated to a residue. The residue was purified by chromatography (SIO₂, ethyl acetate/hexane (3:7)) to give the title compound (0.17 g, 88% yield), Elemental analysis:

calculated - C, 78.42; H, 6.58; N, 3.39 found- C, 78.32; H, 6.48; N, 3.61.

Example 37

step (a)

Combine 5-phenylvaleric acid (89.9 g, 0.504 mol) and SOCI₂ (89.3 mL, 1.225 mol) in a 500 mL round bottom flask equipped with a condenser and drying tube. Heat the flask to 70°C and maintain the reaction at reflux for 1h. Vacuum distill (50 - 100 mm Hg) the excess SOCI₂ and add 200 mL of dry toluene to the remaining mixture.

Vacuum distill a second time to remove the toluene and any residual SOCl₂. Add 188 mL of dry THF to the crude acid chloride remaining in the reaction vessel and use the resulting solution directly in the next step.

step (b)

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Combine 76 g (0.4289 mol) of R-(+)-4-benzyl-oxazolidinone and 1.3 L of dry THF under dry nitrogen atmosphere. Cool the resulting solution to -78°C and add 278 mL of a 1.6 M solution of n-butyllithium in hexane over a period of 30-40 minutes. Stir the mixture for an additional 30 minutes following the addition. Add the solution of 5-phenylvaleroyl chloride from step (a) over a period of 45 minutes. Allow the mixture to warm to 0°C and stir for 1 h. Quench the reaction mixture by adding 673.6 mL of K₂CO₃ (1 M aqueous solution) and stir for 1 h. Distill off the THF under vacuum at 30-35°C. Dilute the residue with 1 L of water and extract with three 800 mL portions of CH₂Cl₂. Combine the organic extracts and wash with 800 mL of water,

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then with 800 mL of brine. Dry the organic extracts over MgSO₄, filter, then concentrate *in vacuo* to an oil. Dissolve the oil in 200 mL of hexane, then distill off the hexane under vacuum. Repeat the hexane treatment two more times, then dissolve the oil in 1.7 mL of CH₂Cl₂. The resulting solution is used directly in the next step.

Cool the solution of the product from step (b) to -5°C to 0°C, under dry nitrogen atmosphere. Add 129.8 mL of di-n-butylboron 10 triflate at a rate that maintains the temperature of the reaction mixture at -6°C to -3°C. Following the addition, stir the mixture for 10 minutes, then add 97.12 mL of diisopropylethylamine at a rate that maintains the temperature of the reaction mixture at -6°C to -3°C. Following the addition, stir the mixture at 0°C for 30 minutes, then cool the mixture to 15 -78°C and stir for 30 minutes. Add 57.4 mL of p-anisaldehyde and stir the mixture at -78°C for 30 minutes, then at 0°C for 1 h. While maintaining the temperature at 0°C to 5°C, quench the mixture by adding 688.2 mL of a pH 7 buffer solution (68 g KH₂PO₄, 12 g NaOH and 800 mL of water), then add 473 mL of 30% H₂O₂ and stir the 20 resulting mixture at 0°C for 1 h. Extract the mixture with three 600 mL portions of hexane:ethyl actetate (1:1). Combine the organic extracts and wash with 800 mL of saturated NaHCO3 (aqueous), then with 800 mL of brine. Dry the organic extracts over NaSO₄, filter, and evaporate to an oil. Crystallize the oil from hexane/ethyl acetate (1:1) to give 176 g 25 of the product as a white solid.

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Combine the product of step (c) (170 g, 0.36 Mol), 1595 mL of THF and 400 mL of water, stir the mixture and cool to about 3°C. Add 226 mL (2.156 Mol) of 30% H₂O₂ to the mixture over 15 minutes, then add a solution of LiOH (36.2 g, 0.862 Mol) in 400 mL of water over a period of 30 minutes. Stir the reaction mixture at 0°C to 5°C for 3 h. Add a solution of 272 g of Na₂SO₃ in 850 mL of water over 70 minutes while keeping the temperature under 27°C. Distill off the bulk of the solvent under vacuum and add 7 L of water. Extract with four 1.7 L portions of toluene. Acidify the aqueous layers to pH 2.4 with 3 N HCl. Extract with one 2.6 L portion and two 1.7 L portions of ethyl acetate. Combine the ethyl acetate extracts, wash with brine, dry over NaSO₄, filter, then evaporate to give the product as a white solid, 112 g.

Combine the product of step (d) (19.47 g, 62 mmol), 400 mL of acetonitrile, 9.49 g (62 mmol) of 1-hydroxybenzotriazole (HOBT), 22.91 g (186 mmol) of p-anisidine and 14.05 g (68.2 mmol) of dicyclohexylcarbodiimide (DCC). Stir the reaction mixture at 40°C for 4 h and confirm the consumption of starting material by TLC (6:4 hexane/ethyl acetate). Concentrate the mixture to 1/3 its volume and partition between 300 mL of water and 300 mL of ethyl acetate. Filter the organic layer, then wash with 200 mL of 1 N HCl, then with two 100 mL portions of saturated NaHCO₃, and two 100 mL portions of brine. Dry the organic layer over NaSO₄ and concentrate to give the product as a solid, 24 g.

step (f)

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Combine the product of step (e) (115 g, 0.2745 Mol) and 2.3 L of THF under dry nitrogen atmosphere and cool to -70°C. Stir the mixture and simultaneously add a solution of 137 mL (0.551 Mol) of tri-n-butylphosphine in 113 mL THF, and 163 mL (1.03 Mol) of diethylazodicarboxylate (DEAD) over 2 h. Allow the mixture to warm to room temperature and stir overnight. Remove the solvent under vacuum. Filter the residue through a plug of silica gel using CH₂Cl₂/hexane/ ethyl acetate (70:24:6) as the eluant. Evaporate the solvent and

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purify the residue by preparative HPLC (silica gel, 15% ethyl actetate/hexane) to give 88 g (80% yield) of the β -lactam product.

<u>Example 38</u>

Cool a solution of 33.7 g (0.1 mol) of the product of Example 37, step (b), in 200 mL of CH₂Cl₂ to -20°C. Stir the cold solution and add 11 mL (0.1 mol) of TiCl₄. Stir the mixture for 10 min. at -20°C, then slowly add 30 mL (2 equiv.) of tetramethylethylenediamine (TMEDA) over a period of 10 min., while keeping the temperature below -10°C. Stir the mixture at -15° to -10°C for 70 min., then add 24 mL (2 equiv.) of p-anisaldehyde. Stir at -15° to -10°C for 1 hour, then allow the mixture to warm to 10°C while stirring for 40 min. Quench the reaction by adding 600 mL of 10% aqueous tartaric acid, then add 600 mL of ethyl acetate. Agitate well, then separate the layers, extracting the aqueous layer with another 200 mL of ethyl acetate. Combine the organic extracts and wash successively with water, saturated NaHCO₃ (aqueous) and brine. Dry the organic solution over anhydrous Na₂SO₄, filter, then concentrate to a residue. Crystallize the residue from a mixture of 100 mL of ethyl acetate + 210 mL of hexane to give 36.8 g of the desired compound, which can be used in step (d) of Example 37.

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5 Step (a)

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Dissolve 500 g (0.85 mol) of the product of Example 37, step(e), in 1700 mL of CH₂Cl₂, then add 4.0 g (12 mmol) of tera-n-butyl-ammonium hydrogen sulfate. Stir the mixture while cooling to 10° to 20°C and add 50% aqueous NaOH (200 g). Slowly add 60 g (285 mmol) of 2,6-dichlorobenzoyl chloride to the stirred mixture over a period of 30 min. Continue stirring at 15° to 20°C for 3 h., then pour the mixture into 2000 mL of cold water. Separate the layers and wash the organic layer with water until neutral pH is attained. Distill the

methylene chloride solution to reduce the volume to 800 mL. Heat the solution to reflux and add 800 mL of heptane. Cool the hot solution to 0°C to crystallize. Collect the product by filtration to give 116 g of the dichlorobenzoate product.

OCH₃

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Combine 500 g (0.85 mol) of the product of step (a) with 250 g (1.1 mol) of benzyltriethylammonium chloride, 2000 mL of CH₂Cl₂ and 8000 mL of methyl t-butyl ether. Stir the mixture while cooling to 15° to 20°C, then add 1000 mL of 50% aqueous NaOH over a period of 10 min. Stir the mixture for 4 h., then pour into 5000 mL of water and 4 kg of ice. Separate the layers and wash the organic layer with water until the pH is neutral. Distill the solvent to reduce the volume to 2000 mL, then filter. Evaporate the filtrate to a residue and purify the residue by chromatography on silica gel to obtain the crude product. Crystallize the product from 6 volumes of a 1:2 mixture of methyl t-butyl ether and heptane at 0°C to give the product (240 g).

5 Step (a):

Dissolve 3.23 g (10 mmol) of the product of Example 37, step (b), in 50 mL of CH₂Cl₂, then stir under nitrogen atmosphere while cooling to -20°C. Add 10 mL (10 mmol) of a 1M solution of TiCl₄ in CH₂Cl₂, stir the mixture for 5 min., then add 1.5 mL (10 mmol) of TMEDA. Stir the mixture at -25° to -20°C for 1 h., then slowly add 4.8 g 5 (20 mmol) of the Schiff's base derived from anisaldehyde and panisidine as a solution in 50 mL of CH₂Cl₂ over a period of 30 min. Stir the mixture at -20°C for 30 min, then gradually warm to 0°C. The reaction is monitored by HPLC (Zorbax® Sil column, 1:4 ethyl acetate/hexane), while stirring at 0°C, until complete. Quench the 10 mixture by pouring into 50 mL of 10% aqueous tartaric acid. Extract with ethyl acetate, then wash the organic extract successively with saturated NaHCO₃ (aqueous) and brine. Dry the organic solution over anhydrous Na₂SO₄, filter, then concentrate to give the crude product. Crystallize from ethyl acetate/hexane to give the purified product. 15

A solution of 0.505 g (0.89 mmol) of the product of step (a)

in 25 mL of CH₂Cl₂ is stirred at 0°C, then treated with 1.77 mL (1.77 mmol) of a 1M solution of sodium bistrimethylsilylamide in THF. Stir the mixture while warming to room temperature, then continue stirring until the starting material is gone as determined by HPLC (typically 1 to 1 1/2 h.) Quench the mixture into 10% tartaric acid (aqueous). Wash the organic layer successively with saturated NaHCO₃ (aqueous) and brine, then dry over anhydrous Na₂SO₄. Filter and concentrate to give the title compound.

The following formulations exemplify some of the dosage forms of this invention. In each the term "active compound" designates a compound of formula I or II, preferably (3R,4S)-1,4-bis-(4-methoxyphenyI)-3-(3-phenylpropyI)-2-azetidinone. However, this compound may be replaced by an equally effective amount of other compounds of formula I or II.

EXAMPLE A Tablets

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No.	Ingredient	mg/tablet	mg/tablet
1 2 3	Active Compound Lactose USP Corn Starch, Food Grade, as a 10%	100 122 30	500 113 40
4 5	paste in Purified Water Corn Starch, Food Grade Magnesium Stearate Total	45 <u>3</u> 300	40 Z 700

Method of Manufacture

Mix Item Nos. 1 and 2 in suitable mixer for 10-15 minutes. Granulate the mixture with Item No. 3. Mill the damp granules through a coarse screen (e.g., 1/4", 0.63 cm) if necessary. Dry the damp granules. Screen the dried granules if necessary and mix with Item No. 4 and mix for 10-15 minutes. Add Item No. 5 and mix for 1-3 minutes. Compress the mixture to appropriate size and weight on a suitable tablet machine.

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EXAMPLE B Capsules

No.	<u>Ingredient</u>	mg/tablet	mg/tablet
1	Active Compound	100	500
2	Lactose USP	106	123
3	Corn Starch, Food Grade	40	70
4	Magnesium Stearate NF	4	Z
	Total	250	700

5 Method of Manufacture

Mix Item Nos. 1, 2 and 3 in a suitable blender for 10-15 minutes. Add Item No. 4 and mix for 1-3 minutes. Fill the mixture into suitable two-piece hard gelatin capsules on a suitable encapsulating machine.

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Using the test procedures described above, the following in vitro and in vivo data were obtained for the preferred compounds, which are referred to in the following table by the corresponding example numbers. For the in vitro ACAT data, negative percent inhibition denotes apparent stimulation, while positive numbers denote inhibition. For the in vivo results, data is reported as percent change versus control, therefore, negative numbers indicate a positive lipid-lowering effect.

	AC	AT (in v	itro)	% Reduction (in vivo)		ivo)
Ex.	IC50	%	Conc.	Serum	Cholest.	Dose
٠.٠	(mM)	Inhib.	(mM)	Cholest.	Esters	mg/kg
1		38	10	-45	-95	50
				-17	-55	10
				0	0	5 ·
1A	7.5	83	25	-10	-26	100
1B		28	10	0	0	50
1C		22	10	-6	-15	50
1D		39	10	О	0	50
1E		3	10			
1F		61	10	0	20	50
1G		21	10	-11	0	50
1H		57	10	-21	-51	50
11	4.5	81	10			
1J	3.0	86	10			
1K		-70	10	0	0	50
1L		20	10	-31	-75	50
				-22	-34	10
				-25	-30	5
1M	7.0	80	10	-11	-31	25
1P		39	10	-19	-54	50
18		-19	10	0	-32	85
1T		-11	10	0	0	50
1U	19	58	10	0	0	50
1V		64	10			
1W		9	10			
1X		9	10	-12	0	50
1Y	 	50	10			
1Z		-15	10	-15	-39	50
1AA		-36	10			
1AB		17	10			
1AC		40	10	-16	-33	50

		_				,
1AD		-5	10			
1AE		-7	10			
1AF		0	10			
1AG		-3	10	-16	-29	50
1AH		4	10			
1AI		27	10			
1AJ		-17	10	0	0	50
1AK		-33	10			
1AL		-43	10	0	0	50
1AM				-12	-29	50
1AN				-34	-85	50
1AO				-33	-78	50
1AP				-51	-95	50
1AQ				-20	-22	50
1AR		-41	10	-22	-25	50
1AS	1.0	83	10	0	-19	50
1AT	5.0	70	10	0	-28	50
1AU		44	10	0	-21	50
1AV		7	10	15	0	50
1AW		68	10	-14	-16	50
1AX				-16	-52	50
1AY				-28	-78°	50
1AZ				-37	-91	50
1BA				0 .	-0	50
1BB		-16	10	0	0	50
1BC		-2	10	0	0	50
1BD		17	10	0	-25	50
1BE		30	10	-10	-21	50
1BF		-17	10	0	-23	50
1BG		3	10	12	0	50
1BH		50	10	0-	0	50
1BI		59	10	-17	-45	50
1BJ		56	10	0	0	50
1BK		55	10	0	0	50

1BL		42	10	-10	0	50
1BM		38	10	0	-21	50
1BN	7.0			-16	0	50
1BO	5.4	79	10	-48	-93	50
1BP		58	10	-9	0	50
1BQ		35	10	0	-17	50
1BR				-15	-70	50
1BS	- <u>-</u> -			0	-43	50
1BT				0	0	50
1BU				-39	-95	50
1BV				-11	0	50
1BW		9		-9	-29	50
1BX				0	0	50
1BY				-18	-72	50
1BZ				-9	0	50
1CA				-12	0	50
1CB		33	10	0	0	50
1CC		46	10	0	0 .	50
1CD	7.0	84	10	0	-23	50
1CE		15	10	-19	-17	50
1CF		53	10	-23	-47	50
1CG		8	10	-30	-61	50
1CH				-49	-95	50
				-41	-90	10
				-24	-80	3
1Cl		26	10	-8	-23	50
1CJ				0	0	50
1CK		-12	10	0	-28	50
1CL		89	10	0	-18	50
1CM				0	0	50
1CN		-28	10	0	0	50
2	6.0	82	10	-15	-37	5
				-28	-69	10
2A	25			0	0	50

	ı 1	1 1		1	1 1	ı
· 3		56	10	0	0	50
3A		33	10	-12	-29	50
3B	6.0	84	10	-11	-16	50
3C		-18	10			
3D	12	42	10	0	0	50
3E		-24	10	0	0	50
3F	1.7	82	10	0	-31	50
3G	5.0	74	10	9	0	50
3H		66	10	-10	31 "	50
31		43	10	-9	0	50
3J		45	10	0	-16	50
3K		19	10	0	0	50
3L		53	10	0	0	25
ЗМ		13	10	0	0	50
3N		62	10	0	0	50
30		-28	10	0	0	50
3Q		3	10	-6	0	50
3R		-8	10	0	0	50
3Т		-9	10			
3U		46	10	0	0	50
3V	6.5	60	10-	0	0	50
3W		56	10	0	0	50
3X		3	10			
3Y		-33	10	0	0	50
4		16	10			
5	18	33	10	-29	-77.5	50
				-20	-72	25
		ļ		-21	-60	10
5A		-70	10			
5C		21	10	-17	-24	50
5D				-38	-95	50
				-41	-94	30
				-24	-77	10
5E				-38	-91	50

						_
II	1			-44	-98	50
5F				-15	-59	30
	Ì			-13	-25	10
				-44	-93	50
5G				-57	-96	50
5H				-26	-70	50
5l				-38	-90	50
5J 5K				-28	-49	50
5K 5L		\		-50	-95	10
SL				-39	-84	3
				-54	-64	1
5M				-8	-36	10
SIVI				-12	0	3
,				-20	-50	50
5N		-23	10	-17	-55	50
5P	<u> </u>	53	10	-11	-33	50
5Q		-36	10	0	-19	50
5R		18	10	-20	-21	50
5S		28	10	-52	-98	50
5T				-15	-48	50
5U				-48	-86	50
5V				-37	-77	50
5W		-16	10	0	-19	50
5X	.	38	10	0	-39	50
5Y	_			-29	0	50
5Z				-16	0	50
5AA				-53	-93	50
5AB	11	30	10	-28	-72	50
6	5	59	10	14	0	50
7				-49	-95	40
•		1		-41	-89.5	10
•		1		-30	-50	3
7A				-22	-54	50
7B				-13	-45	50

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			•	•		
7C				-51	-95	50
7D				-35	-74	50
7E				-52	-93	50
7F				0	-26	50
7J				-21	-27	50
7K				0	-32	50
7L				0	0	50
7M				-38	-94	50
7N				-11	0	50
70				-14	-20	50
7P				-40	-95	50
7Q				-16	0	50
7R				-35	-80	50
7S				-27	-82	50
71				-49	-93	50
7U				-29	-60	50
7V				0	0	50
7W				12	0	50
7X				-26	-78	50
7Y				-53	-94	50
				-27	-79	10
				-22	-55	3
7Z				-21	-39	50
7AA				-10	-42	50
7AC		31	10	0	0	50
7AD		-22	10	-12	-12	50
7AE		-95	10	-17	-10	50
7AF		53	10	23	-15	50
7AG				0	-15	50
7AH		-5	10	16	16	50
7AI				-63	-95	50
		1		-20	-73	10
				-11	-46	3
7AJ				0	-18	50

					_	
7AK				12	-28	50
7AL				-13	0	50
7AM				-24	-70	50
7AN				-12	-42	50
7AO				-41	-90	50
7AP				-24	-82	50
7AQ				-52	-91	50
7AR				-32	-88	50
7AS				0	-20	50
7AT				-10	-32	50
8		-12	10			
8A		-17	10	0	0	50
8B		-5	10	-9	-35	50
8C		63	10	0	0	50
8E				0	-32	50
8F		8	10	-16	-48	50
				-20	-45	25
9	26	30	20	-43	-93	10
				-21.5	-66	5
				-25	-68	3
10A		-37	10	-19	-58	50
11				-8	0	50
12				-12	0	50
12A				-14	-39	50
12B				0	-26	50
12C				0	0	50
12D				0	0	50
13	-			-18	0	50
14				30	-87	50
14A				31	-78	50
14B				0	0	50
14C				0	0	50
15		-6	10	-21	-46	50
15A		2	10	0	0	50

		1	1	ì	t
15B	 -55	10	0	-18	50
16	 42	10	-25	-29	50
16A	 55	10	-30	-53	50
17	 25	10	-17	-52	50
17A	 38	10	-11	-25	50
17B	 		0	-39	50
18	 		0	0	50
19	 24	10	-20	-51	50
19A	 64	10	-20	-34	50
19B	 53	10	-26	-31	50
19C	 		-9	-46	50
19D	 		-15	-18	50
19E	 		-19	-30	50
20	 		12	0	50
21	 		-27	-56	50
21A	 		0	-25	50
22	 ٠		-17	-33	50
22A	 		-16	-22	50
23	 		-22	-40	50
24	 		-17	0	50
24A	 		-21	-76	50
25	 		-8	-34	50
25A	 		-13	0	50
25B	 •••		0	0	50
25C			-8	-46	50
26	 		-4	-26	50
27	 		-12	-36	50
27A	 		-15	-42	50
28	 		-19	0	50
29	 		-22	-24	50
31	 		-19	-52	50
31A	 		О	0	50
32	 		0	0	50
32A	 		О	0	50

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	1 I	1	}	11 _	1.	50
33				0	ľ	
34				-39	-94	50
		18	10	-15	-32	50
35		10	10	ll		50
35A				-34	-84	30
		65	10	-53	-99	50
35B		65	'0	11	04	50
36				-53	-94	130

We claim:

1. A compound having the structural formula

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wherein

A is -CH=CH-B;

-C≡C-B:

-(CH₂)_p-X-B, wherein p is 0, 1 or 2 and X is a bond, -NH-

10 or $-S(O)_{0-2}$;

heteroaryl, benzofused heteroaryl, W-substituted heteroaryl or W-substituted benzofused heteroaryl, wherein heteroaryl is selected from the group consisting of pyrrolyl, pyridinyl, pyrimidinyl, pyrazinyl, triazinyl, imidazolyl, thiazolyl, pyrazolyl, thienyl, oxazolyl and furanyl, and for nitrogen-containing heteroaryls, the N-oxides thereof, and wherein W is 1-3 substituents on the ring carbon atoms selected from the group consisting of lower alkyl, hydroxy lower alkyl, lower alkoxy, alkoxyalkyl, alkoxyalkoxy, alkoxycarbonylalkoxy, (lower alkoxyimino)lower alkyl, lower alkanedioyl, lower alkyl lower alkanedioyl, allyloxy, -CF3, -OCF3, benzyl, R14-benzyl, benzyloxy, R14-benzyloxy, phenoxy, R14-phenoxy, dioxolanyl, NO2, -NR10R11, NR10R11(lower alkyl)-, NR10R11(lower alkoxy)-, OH, halogeno, -NHC(O)OR5, -NHC(O)R5, R6O2SNH-, (R6O2S)2N-, -S(O)2NH2, -S(O)0-2R10, tert-butyldimethylsilyloxymethyl, -C(O)R12 and

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heteroaryl ring nitrogen atoms, when present, are selected from the group consisting of lower alkyl, lower alkoxy, -C(O)OR₅, -C(O)R₅, OH, NR₁₀R₁₁(lower alkyl)-, NR₁₀R₁₁(lower alkoxy)-, -S(O)₂NH₂ and 2-(trimethylsilyl)ethoxymethyl;

30 -C(O)-B; or

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-(CH₂)_k- N R_{13} , wherein k is 1 or 2;

D is B'- $(CH_2)_mC(O)$ -, wherein m is 1, 2, 3, 4 or 5;

B'- $(CH_2)_{q}$ -, wherein q is 2, 3, 4, 5 or 6;

B'-(CH₂) $_e$ -Z-(CH₂) $_\Gamma$, wherein Z is -O-, -C(O)-, phenylene,

5 -NR₈- or -S(O)₀₋₂-, e is 0, 1, 2, 3, 4 or 5 and r is 1, 2, 3, 4 or 5, provided that the sum of e and r is 1, 2, 3, 4, 5 or 6;

B'-(C2-C6 alkenylene)-; B'-(C4-C6 alkadienylene)-;

B'- $(CH_2)_t$ -Z- $(C_2$ - C_6 alkenylene)-, wherein Z is as defined above, and wherein t is 0, 1, 2 or 3, provided that the sum of t and the number of carbon atoms in the alkenylene chain is 2, 3, 4, 5 or 6;

B'- $(CH_2)_f$ -V- $(CH_2)_g$ -, wherein V is C₃-C₆ cycloalkylene, f is 1, 2, 3, 4 or 5 and g is 0, 1, 2, 3, 4 or 5, provided that the sum of f and g is 1, 2, 3, 4, 5 or 6;

B'-(CH₂)_t-V-(C₂-C₆ alkenylene)- or B'-(C₂-C₆ alkenylene)V-(CH₂)_t-, wherein V and t are as defined above, provided that the sum of t and the number of carbon atoms in the alkenylene chain is 2, 3, 4, 5 or 6;

 $B'-(CH_2)_a-Z-(CH_2)_b-V-(CH_2)_{d^-}$, wherein Z and V are as defined above and a ,b and d are independently 0, 1, 2, 3, 4, 5 or 6, provided that the sum of a, b and d is 0, 1, 2, 3, 4, 5 or 6;

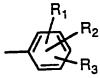
 $T\text{-}(CH_2)_{s^{\text{-}}},$ wherein T is cycloalkyl of 3-6 carbon atoms and s is 1, 2, 3, 4, 5 or 6; or

naphthylmethyl, heteroarylmethyl, or W-substituted heteroarylmethyl, wherein heteroaryl and W are as defined above;

25 B is

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B' is naphthyl, heteroaryl or W-substituted heteroaryl, wherein heteroaryl is as defined above, or

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R is hydrogen, fluoro, C_1 - C_{15} alkyl, C_1 - C_{15} alkenyl, C_1 - C_{15} alkynyl, or B-(CH₂)_h-, wherein h is 0, 1, 2, or 3;

R1, R2 and R3 are independently selected from the group consisting of H, lower alkyl, hydroxy lower alkyl, lower alkoxy, alkoxyalkyl, alkoxyalkoxy, alkoxycarbonylalkoxy, (lower alkoxyimino)-lower alkyl, lower alkanedioyl, lower alkyl lower alkanedioyl, allyloxy, -CF3, -OCF3, benzyl, R14-benzyl, benzyloxy, R14-benzyloxy, phenoxy, R14-phenoxy, dioxolanyl, NO2, -NR10R11, NR10R11(lower alkyl)-, NR10R11(lower alkoxy)-, OH, o-halogeno, m-halogeno, -NHC(O)OR5,

-NHC(O)R₅, R₆O₂SNH-, (R₆O₂S)₂N-, -S(O)₂NH₂, -S(O)₀₋₂R₁₀, tert-- CH₂- N R₁₃

butyldimethylsilyloxymethyl, -C(O)R₁₂,

R₁₃, or R₁ is hydrogen and R₂ and R₃, together with adjacent carbon atoms to which they are attached, form a dioxolanyl ring;

R1', R2' and R3' are independently selected from the group consisting of H, lower alkyl, hydroxy lower alkyl, lower alkoxy, alkoxyalkyl, alkoxyalkoxy, alkoxycarbonylalkoxy, (lower alkoxyimino)-lower alkyl, lower alkanedioyl, lower alkyl alkanedioyl, allyloxy, -CF3, -OCF3, benzyl, R14-benzyl, benzyloxy, R14-benzyloxy, phenoxy, R14-phenoxy, dioxolanyl, NO2, -NR10R11, NR10R11(lower alkyl)-, NR10R11(lower alkoxy)-, OH, halogeno, -NHC(O)OR5, -NHC(O)R5, R6O2SNH-, (R6O2S)2N-, -S(O)2NH2, -S(O)0-2R10, tert-butyldimethyl-

silyloxymethyl, -C(O)R₁₂, R_{13} and R_{13} , or R_{13} , or $R_{1'}$ is hydrogen and $R_{2'}$ and $R_{3'}$, together with adjacent carbon atoms to which they are attached, form a dioxolanyl ring;

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alkyl;

R₄ is , wherein n is 0, 1, 2 or 3, indanyl, benzofuranyl, benzodioxolyl, tetrahydronaphthyl, pyridyl, pyrazinyl, pyrimidinyl or quinolyl;

 R_5 is lower alkyl, phenyl, R_{14} -phenyl, benzyl or R_{14} -benzyl; R_6 is OH, lower alkyl, phenyl, benzyl, R_{14} -phenyl or R_{14} -benzyl; R_7 is lower alkyl, lower alkoxy, OH, halogeno, -NR $_{10}R_{11}$, -NHC(O)OR $_5$, -NHC(O)R $_5$, NO $_2$, -CN, -N $_3$, -SH, -S(O) $_0$ -2-(lower alkyl), -COOR $_9$, -CONR $_{10}R_{11}$, -COR $_{12}$, phenoxy, benzyloxy, -OCF $_3$, or tert-butyldimethylsilyloxy, and where n is 2 or 3, the R_7 groups can be the same or different;

R₈ is H, lower alkyl, phenyl lower alkyl, or -C(O)R₉; R₉ is H, lower alkyl, phenyl or phenyl lower alkyl; R₁₀ and R₁₁ are independently selected from H and lower

15 R₁₂ is H, OH, alkoxy, phenoxy, benzyloxy, -NR₁₀R₁₁, lower alkyl, phenyl or R₁₄-phenyl;

R₁₃ is -O-, -CH₂-, -NH- or -N(lower alkyl)-; and
R₁₄ is 1-3 groups independently selected from the group
consisting of lower alkyl, lower alkoxy, -COOH, NO₂, -NR₁₀R₁₁, OH or
halogeno;

or a pharmaceutically acceptable salt thereof.

- 2. A compound of claim 1 wherein R is hydrogen.
- 3. A compound of claim 1 or 2 wherein D is B'-(CH₂)_q-, B'-(CH₂)_e-Z-(CH₂)_r-, B'-(C₂-C₆ alkenylene)- or B'-(CH₂)_f-V-(CH₂)_g-, wherein B', Z, V, q, e, r, f, and g are as defined in claim 1.
- 4. A compound of claim 3 wherein D is B'-(CH₂)_q- wherein B' is phenyl and q is 3 or 4; B'-(CH₂)_e-Z-(CH₂)_r- wherein B' is p-fluorophenyl or p-methoxyphenyl, e is zero, Z is -O-, and r is 2; B'-(C₂-

 C_6 alkenylene)- is 3-phenyl-1-propenyl; or B'-(CH₂)_f-V-(CH₂)_g- wherein B' is phenyl, f is 1, V is cyclopropylene, and g is zero.

- 5. A compound of claim 1, 2, 3 or 4 wherein A is -(CH₂)_p-X-B wherein wherein X, B and p are as defined in claim 1.
 - 6. A compound of claim 5 wherein p is zero and X is a bond.
- A compound of claim 6 wherein R₁, R₂ and R₃ are selected from the group consisting of H, OH, lower alkoxy, NO₂,
 alkoxyalkoxy, m-halogeno, lower alkyl lower alkandioyl, NR₁₀R₁₁(lower alkoxy)-, allyloxy, phenoxy, alkoxycarbonylalkoxy and -C(O)R₁₂.
 - 7. A compound of claim 1, 2, 3, 4, 5 or 6 wherein R₄ is phenyl, R₇-substituted phenyl or indanyl.
- 8. A compound of claim 7 wherein R₇ is selected from the group consisting of lower alkyl, lower alkoxy, halogeno, -OCF₃, lower alkylthio, -NR₁₀R₁₁, -CN, OH, and -COR₁₂.
- 9. A pharmaceutical composition comprising a cholesterollowering effective amount of a compound having the structure

wherein

R₂₀ is phenyl, W-substituted phenyl, naphthyl, W-substituted naphthyl, benzodioxolyl, heteroaryl, W-substituted heteroaryl, benzofused heteroaryl and W-substituted benzofused heteroaryl, wherein heteroaryl is selected from the group consisting of pyrrolyl, pyridinyl, pyrimidinyl, pyrazinyl, triazinyl, imidazolyl, thiazolyl, pyrazolyl, thienyl, oxazolyl and furanyl, and for nitrogen-containing heteroaryls, the N-oxides thereof;

 R_{21} , R_{22} and R_{23} are independently selected from H or

R₂₀;

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W is 1 to 3 substituents independently selected from the group consisting of lower alkyl, hydroxy lower alkyl, lower alkoxy, alkoxyalkoxy, alkoxycarbonylalkoxy, (lower alkoxyimino)-lower alkyl, lower alkanedioyl, lower alkyl lower alkanedioyl, allyloxy, -CF₃, -OCF₃, benzyl, R₁₄-benzyl, benzyloxy, R₁₄-benzyloxy, phenoxy, R₁₄-phenoxy, dioxolanyl, NO₂, -NR₁₀R₁₁, NR₁₀R₁₁(lower alkyl)-, NR₁₀R₁₁(lower alkoxy)-, OH, halogeno, -NHC(O)OR₅, -NHC(O)R₅, R₆O₂SNH-, (R₆O₂S)₂N-, -S(O)₂NH₂, -S(O)₀₋₂R₁₀, tert-butyldimethyl-

silyloxymethyl, -C(O)R₁₂, ${}^{-CH_2-N}$ ${}^{R_{13}}$ and ${}^{-C-N}$ ${}^{R_{13}}$;

E, F and G are independently a bond; C3-C6 cycloalkylene; C1-C10 alkylene; C1-C10 alkylene; C1-C10 alkynylene; an alkylene, alkenylene or alkynylene chain as defined substituted by one or more substituents independently selected from the group consisting of phenyl, W-substituted phenyl, heteroaryl and W-substituted heteroaryl, wherein heteroaryl is as defined above; an alkylene, alkenylene or alkynylene chain as defined interrupted by one or more groups independently selected from the group consisting of -O-, -S-, -SO-, -SO2-, -NR8, -C(O)-, C3-C6 cycloalkylene, phenylene, W-

substituted phenylene, heteroarylene and W-substituted heteroarylene; or an interrupted alkylene, alkenylene or alkynylene chain as defined substituted by one or more substituents independently selected from the group consisting of phenyl, W-substituted phenyl, heteroaryl and W-substituted heteroaryl; or one of R₂₁-E and R₂₂-F is selected from the group consisting of halogeno, OH, lower alkoxy, -OC(O)R₅,

-NR₁₀R₁₁, -SH or -S(lower alkyl);

 R_5 is lower alkyl, phenyl, R_{14} -phenyl, benzyl or R_{14} -benzyl; R_6 is OH, lower alkyl, phenyl, benzyl, R_{14} -phenyl or R_{14} -

30 benzyl;

 R_8 is H, lower alkyl, phenyl lower alkyl or -C(O) R_9 ; R_9 is H, lower alkyl, phenyl or phenyl lower alkyl;

alkyl;

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R₁₀ and R₁₁ are independently selected from H and lower

R₁₂ is H, OH, alkoxy, phenoxy, benzyloxy,

- N R₁₃

-NR₁₀R₁₁, lower alkyl, phenyl or R₁₄-phenyl;

R₁₃ is -O-, -CH₂-, -NH- or -N(lower alkyl)-;

 R_{14} is 1-3 groups independently selected from the group consisting of lower alkyl, lower alkoxy, -COOH, NO₂, -NR₁₀R₁₁, OH or halogeno;

provided that when G is a bond, R₂₃ is not H, and provided that when R₂₃ is W-substituted phenyl, W is not p-halogeno; or a pharmaceutically acceptable salt thereof;

in a pharmaceutically acceptable carrier.

- 10. A compound of claim 1 selected from those prepared in
 15 examples 1, 1A-1M, 1P, 1AM-1AZ, 1BA-1BZ, 1CA-1Cl, 1CM-1CO, 3, 3A-3O, 5, 5B-5M, 5O-5Z, 5AA-5AB, 7, 7A-7I, 7M-7Z, 7AA, 7AB, 7AE, 7AI-7AK, 7AM-7AU, 8B-8F and 8H.
- 11. A compound of claim 1 or 10 selected from those listed in 20 Table 1.
 - 12. A compound of claim 1, 10 or 11 which is (3R,4S)-1,4-bis-(4-methoxyphenyl)-3-(3-phenylpropyl)-2-azetidinone.
- 25 21. A composition of claim 9 wherein the compound administered is selected from those prepared in examples 1-40..
 - The use of a compound of claim 1 for the manufacture of a medicament for lowering serum cholesterol.
 - The use of a compound of claim 1 for the manufacture of a medicament for inhibiting the enzyme acyl CoA:cholesterol acyl transferase.

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- A process for the preparation of a pharmaceutical composition as claimed in claim 9 which comprises admixing a compound as defined in claim 9 with a pharmaceutically acceptable carrier.
- 25. A method of lowering serum cholesterol levels in a mammal in need of such treatment comprising administering an effective amount of a composition of claim 9.
- 26. A method of inhibiting the enzyme acyl CoA:cholesterol acyl transferase by administering an effective amount of a composition of claim 9 to a mammal in need of such treatment.
- 15 27 A process for producing a compound of claim 1, wherein R is H, and D and A have trans relative stereochemistry, comprising cyclizing a hydroxyamide of the formula

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wherein D, A and R4 are as defined in claim 1, by treating

with:

- (i) a dialkylazodicarboxylate and a trialkylphosphine; or
- (ii) a di- or tri-chlorobenzoyl chloride, an aqueous base and a phase transfer catalyst, then treating the resulting dior tri-chlorobenzoate with an aqueous base and a phase transfer catalyst; or
 - (iii) a dialkylchlorophosphate, an aqueous base and a phase transfer catalyst; or
 - (iv) a di- or tri-chlorobenzoyl chloride and an alkali metal hydride.

28. A process for producing a compound of claim 1 having the formula

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wherein D, A and R4 are as defined in claim 1, comprising:

(a) reacting a carboxylic acid of the formula DCH₂-

COOH, wherein D is as defined above, with a chlorinating agent;

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(b) deprotonating a chiral oxazolidinone of the formula

wherein R¹⁸ and R¹⁹ are independently selected from the group consisting of: hydrogen, C₁-C₆ alkyl, phenyl, naphthyl, substituted phenyl, substituted naphthyl, and benzyl; with a strong base and treating the resulting anion with the product of step (a);

- (c) enolizing the product of step (b) with either:
 - (i) a dialkylboron triflate and a tertiary amine base;
 - (ii) TiCl₄ and tetramethylethylenediamine (TMEDA) of TMEDA and triethylamine:

or a mixture of TMEDA and triethylamine;

then condensing with an aldehyde of the formula A-CHO, wherein A is as defined above;

- (d) hydrolyzing the product of step (c) with a base and hydrogen peroxide;
- 25 (e) condensing the product of step (d) with an amine of the formula R⁴NH₂, wherein R⁴ is as defined above, by treating with a dehydrative coupling agent, optionally adding an activating agent; and
 - (f) cyclizing the product of step (e) by treating with:

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(i) a dialkylazodicarboxylate and a trialkylphosphine; or

(ii) a di- or tri-chlorobenzoyl chloride, an aqueous base and a phase transfer catalyst, then treating the resulting dior tri-chlorobenzoate with an aqueous base and a phase transfer catalyst; or

(iii) a dialkylchlorophosphate, an aqueous base and a phase transfer catalyst; or

(iv) a di- or tri-chlorobenzoyl chloride and an alkali metal hydride.

29. A process for producing a compound of claim 1, wherein R is hydrogen, and D and A have trans relative stereochemistry, comprising:

(a) enolizing a compound of the formula

with TiCl₄ and tetramethylethylenediamine (TMEDA), then condensing with an imine of the formula A-CH=N-R⁴, wherein A and R⁴ are as defined above, and wherein the group

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wherein R¹⁸ and R¹⁹ are independently selected from the group consisting of: hydrogen, C₁-C₆ alkyl, phenyl, naphthyl, substituted phenyl, substituted naphthyl, and benzyl; and

(b) cyclizing the product of step (a) by treating with a strong non-nucleophilic base.

30. A process for preparing compounds of claim 1 comprising:

(a) treating an ester of the formula D-CH(R)-C(O)OR¹⁷, wherein R¹⁷ is lower alkyl, menthyl, or 10-(siisopropylsulfonamido)-isobornyl, with a strong base, and then with an imine of the formula A-CH=N-R⁴, wherein A and R⁴ are as defined in claim 1; or

- (b) for preparing a compound of claim 1 wherein R is not hydrogen, reacting a compound of claim 1, wherein R is hydrogen, with a strong base and an alkylating agent or an acylating agent; or
- (c) for preparing a compound of claim 1, wherein R is hydrogen, and D and A have cis relative stereochemistry, reacting a compound of claim 1, wherein R is hydrogen, and D and A have trans relative stereochemistry, with a strong base at -80° to -40°C, and then with a proton source; or
- (d) for preparing a compound of claim 1, wherein R is hydrogen, and D and A have trans relative stereochemistry, reacting a compound of claim 1, wherein R is hydrogen, and D and A have cis relative stereochemistry, with an alkali metal t-butoxide, then quenching with acid; or
 - (e) reacting a carboxylic acid derivative of the formula D-CH(R)-C(O)-Z, wherein D and R are as defined in claim

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the formula A-CH=N-R 4 , wherein A and R 4 are as defined in claim 1, in the presence of a tertiary amine base.

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According to International Patent Classification (IPC) or to both National Classification and IPC Int.Cl. 5 CO7D205/08; CO7D205/085; CO7D401/04; CO7D405/10; CO7D405/04; CO7D409/04; IL FIELDS SEARCHED Minimum Documentation Searches?	C07D403/04 A61K31/395
Minimum Documentation Searches?	
Classification System Classification Symbols	
Int.C1. 5 CO7D ; A61K	
Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched	1
III. DOCUMENTS CONSIDERED TO BE RELEVANT ⁹	Reignant to Claim No.
Category Citation of Document, 11 with indication, where appropriate, of the relevant passages 12	Elevant to Class 110
EP,A,O 199 630 (MERCK & CO., INC.) 29 October 1986 see claims	1-9, 22-30
EP,A,O 337 549 (MERCK & CO., INC.) 18 October 1989 see claims	1-9, 22-30
A EP,A,O 365 364 (TAISHO PHARMACEUTICAL CO.) 25 April 1990 see claims	1-9, 22-30
A EP,A,0 375 527 (CNRS) 27 June 1990 see claims	1-9, 22-30
P,A EP,A,O 462 667 (MERCK & CO., INC.) 27 December 1991 see claims	1-9, 22-30
-/-	-
**Comment defining the general state or the art which is not considered to be of particular relevance inventions: "It document which may throw doubts on priority claims(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means- "P" document published prior to the international filing date but later than the priority date claimed "A" document research for particular relevance involve an inventive step involve an inventive step cannot be considered to involve an inventive step. "Y" document of particular relevance cannot be considered in involve an inventive step involve an invention invention invention.	nflict with the application out iple or theory underlying the unon; the claimed invention a cannot be considered to unon; the claimed invention ive an inventive step when the ne or more other such document or more other such document or a person skilled.
IV. CERTIFICATION	ordered Second Devem
Date of the Actual Completion of the International Search 15 OCTOBER 1992 2 3	3. 11. 92
EUROPEAN PATENT OFFICE Signature of Authorized Office CHOULY J.	

	International Application No I DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)					
	NTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET) Citation of Document, with indication, where appropriate, of the relevant passages	Relevant to Claim No.				
riegory °	Citation of Document with toutestion, where spin-					
P,A	EP,A,O 481 671 (MERCK & CO., INC.) 22 April 1992 see claims	1-9, 22-30				
	·					

INTERNATIONAL SEARCH REPORT

Box I	Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)
This inu	ernational search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:
ı. 🔲	Claims Nos.: because they relate to subject matter not required to be searched by this Authority, namely: Remark: Although claims 25,26 are directed to a method of treatment of (diagnostic method practised on) the human/animal body the search has been carried out and based on the alleged effects of the compound/composition.
2.	Claims Nos.: because they relate to parts of the international application that do not comply with the prescribed requirements to such because they relate to parts of the international application that do not comply with the prescribed requirements to such because they relate to parts of the international search can be carried out, specifically:
3.	Claims Nos.: because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).
Box II	Observations where unity of invention is lacking (Continuation of item 2 of first sheet)
	ternational Searching Authority found multiple inventions in this international application, as follows:
ı. [As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2	As all searchable claims could be searches without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3	As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4.	No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO. US

9205972 62862

This amore lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The members are as contained in the European Patent Office EDP file on The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information. 15/10/92

Patent document cited in search report	Publication date		Patent family member(s)		Publication date
EP-A-0199630	29-10-86	US-A- JP-A-	4680391 61289074		1-07-87 9-12-86
EP-A-0337549	18-10-89	AU-A- AU-A- JP-A-	1858292 3263089 2006471	12)-09-92 2-10-89)-01-90
EP-A-0365364	25-04-90	CA-A- JP-A- US-A-	2000437 2191249 4952689	27	0-04-90 7-07-90 3-08-90
EP-A-0375527	27-06-90	FR-A- AU-A- CA-A- JP-A- US-A-	2640621 4691789 2005759 3034966 5030628	2: 19 14	2-06-90 L-06-90 3-06-90 4-02-91 3-07-91
EP-A-0462667	27-12-91	US-A- CA-A-	5120729 2044906		9-06-92 1-12-91
EP-A-0481671	22-04-92	AU-A-	8583391	19	9-12-91